Reducing free sugar intakes:
Evidence for effective dietary recommendations

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Dedication

This work is dedicated to the one who makes all things for good, those that helped along the way, and those there at the start but not at the end.

Copyright statement

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Abstract

Reducing free sugar intakes: Evidence for effective dietary recommendations

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Large scale epidemiological investigations and RCT trials since the 1990's have shown that diet is a leading risk factor for many communicable and non-communicable diseases. Within this research, diets high in free sugar intakes have been linked to conditions such as poor oral health, cardiovascular disease, obesity, depression and anxiety. Agencies such as the World Health Organisation have advocated for the use of food-based dietary guidelines to aid against the effects of poor diets, including those high in free sugars. Since then, over 90 countries have released their own national dietary guidelines, with many monitoring their nation's diets through programmes such as the UK's National Diet and Nutrition Survey. Analysis of national reports have highlighted poor adherence to national dietary recommendations. Additionally, assessments into the effectiveness of these dietary recommendations are poor, with most countries having no way to monitor the impact of recommendations. This thesis sought to assess the research question of; what is the impact of current reducing free sugar advice, and its component nutrient, food and swap level advice on reducing free sugar intakes? The primary outcome was percentage free sugar intakes (FS%) and adherence to recommendations at an endpoint of 12 weeks. Secondary outcomes were assessed for a range of demographic, behavioural and taste variables, with qualitative interviews undertaken to investigate barriers and facilitators to intervention success.

Using a randomised controlled parallel-group trial, 242 adults (18-65 years) were randomised across four trial arms to receive nutrient-based (N) (n=61), nutrient- and food-based (NF) (n=60), nutrient-, food- and food-substitution-based recommendations (NFS) (n=63) or no recommendations regarding free sugar intake (control, n=58). Data were analysed with intention to treat protocol and multiple imputation used in the case of missing data. Endpoint attrition was 17.5%. In the primary analyses, multiple regression models significantly predicted endpoint free sugar percentage intakes (FS%)(F(7,234) = 8.86, p<0.001, R^2=0.21. Significant predictors were recommendations received (B=-0.636, p=0.029), baseline %FS (B=0.377, p<0.001) and baseline bodyweight (B=-0.04, p=0.041). The

mean %FS reduced in all intervention groups N, NF, NFS by 2.47%, 3.25%, 3.08% respectively, in comparison to no change in the control group (-1.18%). Endpoint bodyweight was significantly predicted, $F(6,235) = 1404.355$, $p < 0.001$, $R^2 = 0.97$, adj R^2 0.97 with only the baseline bodyweight ($b = 0.952$, $p = 0.001$) and age ($b = -0.032$, $p = 0.048$) variables adding statistically significantly to the prediction. There was a weak association between endpoint bodyweight and group ($b = -0.359$, $p = 0.062$). The mean endpoint bodyweight reduced in all intervention groups N, NF, NFS by 0.72kg, 1.44kg, 1.11kg respectively, in comparison to no change in the control group (-0.17kg). In exploratory analyses, change in: FS%, bodyweight and waist circumference was significantly correlated with summative adherence scores. Linear regression analyses found summative adherence significantly predicted change in FS%. Framework analysis of participant interviews identified seven themes and fourteen subthemes for investigations of barriers and facilitators to recommendations which provided insight when considering quantitative findings.

Primary results show that providing participants with N, NF or NFS guidelines reduced FS% at an endpoint of 12 weeks. This supports the use of national dietary guidelines for dietary change. The average reduction of ~3% intakes achieved the same level of reduction as multiple years of the 'Sugar reduction programme' which included the same supporting aims of aiding in the reductions of free sugar intakes for the UK public. It was encouraging that the most adherent individuals had the largest reduction in FS%, but disappointing that national goals of <5 FS% intakes remained unmet. As seen worldwide, it is likely that poor adherence to dietary guidelines will be a persistent factor irrespective of information type provided. A limitation within this research was the potential of underreporting of sugar intakes. Underreporting is common across dietary monitoring trials, however, is of higher risk in the reporting of foods high in sugar, fat or salt. A second limitation can be regarded as participants completing their own research on reducing intakes. This does emulate what individuals are likely to do in a real-world context and was mentioned in participant interviews however, it makes observing differences between different recommendations less likely. This trial supports the use of simple targeted interventions for gradual dietary and physical change, with adherence being vital for long-term benefits. Further research is needed to identify individual factors for more effective dietary advice to be delivered on broader national scale rather than a one-size-fits-all approach.

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Abbreviations

AHC Agglomerative hierarchical clustering

BMI Body mass index

BU Bournemouth University

BW Bodyweight

CCA Complete case analysis

CG Control group

CHOICE Choose Healthy Option Consciously Everyday

COMA Committee on Medical Aspects of Food and Nutrition Policy

COREQ Consolidated Criteria for Reporting Qualitative Research

CR Cognitive restraint

CVD Cardiovascular disease

DLW Doubly labelled water

EE Emotional eating

ERG External reference group

FA Framework analysis

FBDG Food-based dietary guidelines

FCQ Food Choice Questionnaire

FCS Fully conditional specification

FS% Free sugar intakes %

gLMS Generalized Labelled Magnitude Scale

GSLTPAQ Godin-Shephard Leisure Time Physical Activity Questionnaire

MCS Mental component summary

MI Multiple imputation

N Nutrient group

NCD Non-communicable disease

NDNS National Diet and Nutrition Survey

NF Nutrient and food group

NFS Nutrient, food and swaps group

NHS National Health Service

NICE The National Institute for Health and Care Excellence

NSF	Non sweet foods
NS-SEC	National Statistics Socio-economic Classification
ONS	Office of national statistics
PCS	Physical component summary
PGR	Postgraduate researcher
PHE	Public Health England
PMM	Predictive mean matching
PROP	6-n-Propylthiouracil
RCT	Randomised controlled trial
RNI	Reference nutrient intakes
SACN	Scientific Advisory Committee on Nutrition
SDIL	Soft Drink Industry Levy
SES	Socioeconomic status
SF	Sweet foods
SF-36	36-Item Short Form Survey
SI	Single imputation
SPSS	Statistical Package for the Social Sciences
SQ	Sweet Questionnaire
SSB	Sugar-sweetened beverages
TD1	Test Day 1
TE	Total energy
TEI	Total energy intakes
TFEQ	Three Factor Eating Questionnaire
TLA	Taste liquid A
TP	Timepoint
TPA	Taste paper A
TPB	Taste paper B
TW	Total weight
UE	Unregulated eating
VAS	Visual analogue scales
WC	Waist circumference
WHO	World Health Organization

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1. Introduction

This chapter will introduce the context of this thesis by firstly outlining global and UK dietary guidelines. The topic of dietary guidelines includes an overview of dietary guidelines, definition of free sugars and specific free sugar dietary recommendations. The context this research sits in will then be discussed covering the health impacts of diet, current global diets, further impacts of dietary intakes, and adherence to dietary recommendations, before summarising in a statement of the problem. Definitions of nutrient, food and swap level information are then outlined with examples from UK free sugar recommendations provided. Following this, a systematic review of evidence from literature regarding nutrient, food and swap level interventions will be discussed. Finally, this study's contribution to the field of knowledge, its aims and objectives will be outlined. Figure one below outlines the sections of this chapter, with the topics of global perceptions, UK perception, sugar focus, and nutrient, food and swaps advise focus, discussed throughout the directed chapter sections.

Figure 1.1: Outline of introduction thesis chapter

1.1. Dietary guidelines

1.1.1. Global dietary guidelines

The earliest dietary guidance was published over 100 years ago in 1894 by the U.S Department of Agriculture in their Farmer's Bulletin (Atwater, 1894). Atwater (1894) recommended dietary intakes for American males should be based on protein, carbohydrates, fat and 'mineral matter' (Atwater, 1894). These early recommendations predated even the discovery of many vitamins and minerals in the early 1900s (Mozaffarian et al., 2018). Nutritional research has come a long way in the last century, from the identification of vitamins (<1950), fortification of crops (1960), links between diet and disease (1980), to the creation and reformulation of advice for complex dietary patterns (2000+) (Mozaffarian et al., 2018). Despite this long timeline of research, modern nutritional science and dietary recommendation research are perhaps still in their infancy.

In 1998, the World Health Organization (WHO) and Food and Agriculture Organization (FAO) advised dietary recommendations should be based on foods, since foods, not nutrients, determine dietary choices and because promoting changes to entire dietary patterns will help achieve multiple single-nutrient goals (World Health Organization & Food and Agriculture Organization of the USA, 1998). National dietary guidelines were therefore put forward to help address health concerns. The promotion of these healthy food messages are designed to educate and aid the public in their food choices by simplifying technical nutrient intake values. In the design of dietary guidelines, the FAO and WHO recommended that identifying empirical and statistical evidence for the relationship between nutrients intakes and health be the cornerstone (World Health Organization & Food and Agriculture Organization of the USA, 1998). While this evidence is still valid, what is considered valid evidence may vary greatly across the globe, with more rigorous methods available such as regular systematic reviews of policy and investigations into the effectiveness of guidance. This review process, often undertaken by government agencies and expert committees, considers wider evidence from the socioeconomic landscape and culture (Blake et al., 2018).

National dietary guidelines and policies vary by country, however as a recent review (Herforth et al., 2019) outlines, many are visual messages of food-based dietary guidelines (FBDG), with nutrient level advice providing the evidence for FBDG and data on ingredient lists, nutritional labelling, and reference nutrient intake levels (RNI) for the individual (Herforth et al., 2019). Prominent examples of national dietary guidelines include the Eatwell Guide for the United Kingdom (Public Health England, 2016b), the Australian Dietary Guidelines (The National Health and Medical Research Council (NRMRC), 2013), and Dietary Guidelines for Americans (U.S. Department of Agriculture & U.S. Department of Health and Human Services, 2020). In a 2018 review (Blake et al., 2018) of 32 countries, the types of evidence used to inform FBDG included previous versions of guidance (71.9%); guidance from other countries (56.3%), current reports by authoritative bodies (75%), current systematic reviews (12.5%), and other evidence review types (25%) (Blake et al., 2018). Blake et al, 2018 criticised the creation of FBDG, claiming that too many ‘inconsistencies’ in methods for evidence review exist, with the decision-making underpinning nutritional policy needing to be more ‘systematic’ and ‘transparent’(Blake et al., 2018).

As shown in the review by Herforth et al. (2019), of over 90 countries FBDG, there is a global consensus on the messages contained nationally within dietary guidance, with >50% recommendations including common key messages such as (Herforth et al., 2019):

- Encouraging fruit and vegetable intake.
- Lean protein sources (e.g., poultry and legumes).
- Include sources of dairy in the diet.
- Visual food guide display (pyramid, circle, plate or culture reference).
- Messages regarding diet and food portions.
- Messages regarding, sweets, sugars, fats, water and exercise.

As evidence continually emerges the clarification and boundaries on what constitutes a healthy diet also changes. Most of the guidelines discussed in this research and promoted in nations around the globe generally align with the WHOs ‘Global Action Plan for the Prevention and Control of Noncommunicable Diseases’(WHO, 2013).

The use of FBDG can be criticised for often being based on observational data and epidemiological research, rather than the ‘gold standard’ of RCT investigations. As the recommendations require substantial reliable information before messages can be communicated to the public, it is likely that they will not adapt fast enough becoming outdated. Countries such as the USA update and review their dietary guidance every 5 years, with the 2020-2025 guidelines published (U.S. Department of Agriculture & U.S. Department of Health and Human Services, 2020) and work already underway for the 2025-2030 guidelines (U.S. Department of Agriculture & U.S. Department of Health and Human Services, n.d.). This is by no means the common trend for FBDG across the world. The majority of FBDG were published before 2015, with very few continually updated since publication (Herforth et al., 2019). Even then, updates are likely to be based on previous versions of advice without adaption for new cultural trends and practises, such as emergent patterns in the consumption of ultra-processed foods (Lane et al., 2024). It was reported that in westernised diets of individuals in the USA and Canada, ultra-processed foods represented up to 80% of the total caloric intake, with the average for the UK at 57% between the years 2008-2014 (Martini et al., 2021). As FBDG disseminate information to provide diets of suitable nutritional value, we could be at risk of not optimising our nutritional status by not acknowledging the impact high proportion ultra-processed diets now have. Furthermore, it has been observed that high exposure to ultra processed foods is associated with increased risk of adverse health and mortality outcomes (Lane et al., 2024). These changing trends in consumption patterns in combination with potential health risks highlight the need for not just the content of dietary guidelines to be reviewed, but the question of the evaluating the review process itself.

A healthy balanced diet can be defined as providing all the essential macro and micronutrients within the appropriate proportions to maintain physical health, mental health and development, while preventing deficiency and disease. As outlined in the UK's dietary guidelines (Public Health England, 2016b) and similar global guidance (World Health Organization, 2003b), to have a balanced diet individuals should aim for the following:

- Consume >5 portions of fruit and vegetables daily.
- Base meals on starchy carbohydrates (>50% daily intakes).
- Consume a source of milk, dairy or alternative (choosing low fat).
- Switch to unsaturated fat spreads and oils, with these items eaten in small amounts.
- Consume 6-8 glasses of fluid (water, low-fat milk etc) a day.
- Aim for 2 portions (140g) of fish a week, with one to be oily (e.g., mackerel).
- Limit total fat (no more than 35% TEI) saturated fat (no more than 11% TEI), sugar (<5% intakes TEI) and salt intakes (<6g/daily).

1.1.2. UK dietary guidelines

The first national food based dietary guidance was introduced to the UK in 1994, in the 'The Balance of Good Health' model (Public Health England, 2016a). The Balance of Good Health model was visually developed based on consumer research and included a titled segmented plate with a knife and fork outlining dietary constituents (Hunt et al., 1995; Public Health England, 2016a). This model was largely considered a useful aid by professionals, however since 2000 there have been calls for it to be updated. In 2007 this was revised into 'The Eatwell Plate', with the imagery overhauled into a brighter, more engaging and simpler message, however it still retained the iconic plate design (Public Health England, 2016a).

In June 2014, shortly after the inception of Public Health England (PHE), the paper 'Sugar reduction – Responding to the challenge' (Public Health England, 2014, 2016a), committed to reviewing the Eatwell plate. This was largely in response to updated dietary guidance on sugars and fibre as outlined in the Scientific Advisory committee on Nutrition's (SACN) report on carbohydrates and health (Public Health England, 2016a; Scientific Advisory Committee on Nutrition, 2015). The updated and retitled 'Eatwell Guide' (Public Health England, 2016b) was then published in March 2016. The 'Eatwell Guide' outlines FBDG that have been developed in order to meet the nation's dietary reference values (DRV). This guidance aims to translate often complex DRV's into visualised food-based guidance. In the UK, national dietary guidance is reflective of evidence gathered from the Committee on Medical Aspects of Food and Nutrition policy (COMA) and its successor in 2000, SACN. The national diet and nutrition survey (NDNS) provides up to date information on the current food intake patterns of the nation (Public Health England, 2016a).

In order to refresh the Eatwell Guide an external reference group (ERG) was set up to advise PHE on how to approach revising the Eatwell Plate, although, it is important to note the ERG was not asked to approve the final version of the Eatwell Guide. The methods for reformulating the Eatwell Plate can be broken into two areas, linear programming, and consumer research (Public Health England, 2016a). The Nuffield Department of Population Health, at the University of Oxford was tasked with completing the linear programming. This methodology investigates the current dietary habits of the population and the divergence from the idealised modelled diet, resulting in recommendations that have the fewest number of changes required to meet dietary recommendations (Public Health England, 2016a). Consumer research and qualitative investigations into the understanding and communication of dietary messages was undertaken by Define Research and Insight Ltd to ensure consumers responded well to design changes, and that messages were viewed as both accessible and engaging to a diverse consumer base (Public Health England, 2016a). As both of these areas were recommended by the ERG and completed independently of PHE, the findings offered objective recommendations for the refreshing of the Eatwell Guide.

Since 2016 the Eatwell Guide has not been updated and could be considered as outdated in comparison to other countries recommendations such as the Dietary guidelines for Americans (U.S. Department of Agriculture & U.S. Department of Health and Human Services, 2020). There is no justifiable reason for this lack of update, especially considering the clear links between sugar intakes and dental carries (Feldens et al., 2022). It can be considered negligent of countries such as the UK which have the capacity to update these reports but have not prioritised it. Using the example of free sugar intakes, PHE advised that intakes of free sugars should be less than 5% total energy intakes (TEI) to be optimal for health. This message was adapted into advice on how to cut down on sugar intakes as found in the 'Eatwell Guide' (Public Health England, 2016b). However, as recent reports have highlighted the high consumption patterns of ultra processed foods, of which confectionary and sugar-sweetened beverages (SSB) are the biggest contributors (Martini et al., 2021) the evaluation of free sugar guidance specifically is imperative. It is possible communication and guidance for reducing these intakes is sufficient to produce change, but we don't know. Alternatively, issues such as advice being outdated and culturally behind may adversely impact their effectiveness more than we anticipate.

1.1.3. Definition of free sugars

Free sugars are succinctly defined in the SACNs 2015 report on Health and Carbohydrates (Scientific Advisory Committee on Nutrition, 2015) and includes:

> All monosaccharides (e.g., glucose and fructose) and disaccharides (e.g., sucrose) added to foods by the manufacturer, cook or consumer, plus sugars naturally present in honey, syrups and unsweetened fruit juices. Under this definition, lactose (the sugar in milk) when naturally present in milk and milk products and the sugars

contained within the cellular structure of foods are excluded (Scientific Advisory Committee on Nutrition, 2015).

This UK definition aligns with the WHOs definition for a consistent global consensus on the definition of free sugars (Scientific Advisory Committee on Nutrition, 2015; World Health Organization, 2015).

Free sugars are distinct and different from those that occur naturally in unprocessed fruits, vegetables, and dairy. Sugar in the unprocessed form is accompanied by other cellular structures such as fibre (Scientific Advisory Committee on Nutrition, 2015). Therefore, whole foods require digestion before sugars can be absorbed by the body on consumption. Once these foods have been processed, e.g., juiced, the sugar is no longer bound by the intact cellular structure and the resulting food, e.g., fruit juice, is now defined as a free sugar item. To summarise the designation "free" explains that sugars naturally present in foods such as fruits and vegetables have been unbound from their cellular structure and are freely available on consumption (Scientific Advisory Committee on Nutrition, 2015; Swan et al., 2018; World Health Organization, 2015). For reference table 1.1 below is adapted from the paper titled "A definition of 'free sugars' for the UK" (Swan et al., 2018) and outlines the boundaries of what is included and excluded with the term 'free sugars.'

Table 1.1: Free sugars definition

Included	Excluded
Honey, syrups and nectars – added by manufacturer or consumed (e.g., glucose syrup)	Maltodextrins, oligofructose and sugar substitutes such as polyols (sorbitol).
Lactose and galactose added as an ingredient to foods or drinks (e.g., lactose in whey powder)	Naturally present lactose and galactose including milk; dairy-based drinks and milk powder.
Fruit and vegetable juices, concentrates, smoothies, purées, pastes, powders and extruded fruit and vegetable products.	Intact dried, stewed, canned and frozen fruit and vegetables (including beans and pulses).
Sugars in drinks except for dairy-based including all sugar in: • fruit and vegetable juice/concentrates/purees, • alcoholic drinks; • dairy-alternative such as soya, oat and cashew.	Sugars naturally present in puréed and powdered potatoes and other starchy staples. Sugars naturally present in cereal grains including rice, pasta and flour regardless of processing (other than cereal-based drinks) Sugars naturally present in nuts and seeds regardless of processing (other than nut-based drinks)

Footnotes: Information taken and adapted from Swan et al. 2018

It was important to classify a definition of free sugars within this thesis as in nutritional literature there has been some ambiguity surrounding the language used to describe sugars (Lai et al., 2019; Schorin et al., 2012; U.S. Food and Drug Administration, n.d.). For example, an accepted alternative name for 'free sugars' is non-milk extrinsic sugars (NMES). NMES are sugars that are not from dairy or integrated in the cellular matrix with some slight differences in the categorisation of dried and canned fruits (Lai et al., 2019). Furthermore, the term 'added sugars' is often used interchangeably in research to mean 'free sugars', but the terms are different (Schorin et al., 2012; Swan et al., 2018). Added sugars refers to sugar or syrup that has been added to foods during preparation or at the table (U.S. Food and Drug Administration, n.d.). For example, a glass of orange juice may be considered devoid of 'added sugars', as nothing has been added. However, orange juice will be considered a high free sugar item as the sugars have been released from the cellular matrix via juicing.

1.1.4. Global free sugar recommendations

In 2015, the WHO published their guideline on 'sugar intakes for adults and children' (World Health Organization, 2015). To summarise, their recommendations were as follows:

- *'WHO recommends a reduced intake of free sugars throughout the life course (strong recommendation).*
- *In both adults and children, WHO recommends reducing the intake of free sugars to less than 10% of total energy intake (strong recommendation).*
- *WHO suggests a further reduction of the intake of free sugars to below 5% of total energy intake (conditional recommendation.'*(World Health Organization, 2015)(pg.4).

In Herforth and colleagues' (Herforth et al., 2019) global review of dietary guidelines, more than 90 countries were investigated for their dietary guidance. In advice specifically relating to sugar, they found that 95% of the guidelines included a visual/graphical message to limit sugar intakes, which was a key message in 84% of countries. Despite sugar's obvious importance to health as discussed earlier in this review, only two countries currently have quantitative sugar reduction messages in line with the WHO's 10% guideline, the United Kingdom (2015), (Scientific Advisory Committee on Nutrition, 2015) and the United States (2020), (U.S. Department of Agriculture & U.S. Department of Health and Human Services, 2020).

The UK echoed the WHO's recommendation (World Health Organization, 2015) in SACNs 2015 report titled 'carbohydrates and health' (Scientific Advisory Committee on Nutrition, 2015) stating.

- '*SACN is recommending that population average intake of free sugars should not exceed 5% of total dietary energy'* (Scientific Advisory Committee on Nutrition, 2015).

1.1.5. UK free sugar guidelines

The United Kingdom has been at the forefront internationally for its efforts in tackling free sugar intakes. The section will discuss the initiatives implemented by government and policy with commentary on some of the effectiveness of this to date. In 2015 alongside the reformulation of the Eatwell Guide (Public Health England, 2016a), SACN published their recommendation that both adults and children should not exceed 5% of TEIs from free sugars (Scientific Advisory Committee on Nutrition, 2015). The is equal to approximately 30grams of sugar for adults. Following on from this, the UK governments Childhood Obesity Plan in 2016 (HM Government, 2016) put forward the 'Sugar Reduction Programme'. The 'Sugar Reduction Programme' aimed to reduce the overall sugar content of children's sugar intakes by 20% by 2020 (HM Government, 2016; Public Health England (PHE), 2017). In 2017, Public Health England outlined that this 20% reduction in sugar content may be achieved via three main routes; product sugar reformulation; nutrient content of portion sizes; and consumer buying habits. However, in the assessment of the effectiveness of this programme only changes in product reformulation were reported. It was also noted that the reduction of sugar in products should not be at the consequence of increases in saturated fat, salt, or calorie content. The following food categories were suggested as areas of product reformulation, including but not limited to; breakfast cereals, yogurts, ice cream and juice (HM Government, 2016; Public Health England, 2019; Public Health England (PHE), 2017).These targets represent nutrient level interventions for industry with the recognition that specific foods may be more likely to contain higher levels than others.

The design of the 'Sugar Reduction Programme' was largely considered due to the success of the UK governments policies regarding their 'Salt Reduction Programme' (He, Brinsden, et al., 2014). In 2004 the UKs 'Food Standards Agency' introduced the 'Salt Reduction Programme' (Public Health England, n.d.); initial progress was heralded as a success (He, Brinsden, et al., 2014) with reductions in the nation's salt intakes a likely contributor to reductions in blood pressure between 2003 and 2011 (He, Pombo-Rodrigues, et al., 2014). There was a statistically significant downward trend in the UK salt intakes between 2005-2009, however NDNS reports show no significant changes from this point with linear trends between 2009-2019 close to zero for the population (Public Health England, 2020). Additionally In 2018/2019 the average intake of salt for UK adults (19-64 years) was 8.4g/day, (40% higher that the recommended 6g/day limit)(Public Health England, 2020). Despite slowing progress in recent years on the 'Salt Reduction Programme', it has shown that having specific targets and continuing monitoring (Public Health England, 2020c) for both the government and food manufacturers was beneficial for reducing salt intakes and subsequently the associated health risks. This is something the 'Sugar Reduction Programme' may be criticized for lacking in clarity (Action on Sugar, 2022).

Initially the 'Sugar Reduction Programme' had some success, seeing a 2% reduction in the sugar content of foods in year 1. This programme included the introduction of the Soft Drink Industry Levy (SDIL), which became law in 2018. The SDIL was found to produce reductions of 34.3% in total sugar sales from soft drinks between 2015 and 2020 (Office for Health Improvement & Disparities, 2022). These reductions in total sugar sales are even more impressive considering soft drinks sales (products in all 3 sugar tiers) increased by 21.3% across the same time period. These reductions of total sugar sales are attributed to the shift from higher sugar content soft drinks (>5g of sugar per 100ml) to those of a lower sugar content (<5g of sugar per 100ml) (Office for Health Improvement & Disparities, 2022). Despite being short of the 5% target, this proved that industry changes were somewhat effective. Unfortunately, progress appeared to have then stagnated with only a 3.5% reduction reported at the end of year 4 (2020) (Office for Health Improvement & Disparities, 2022). Therefore the 20% guideline was not achieved.

In the evaluation of this programme, it is worth considering what was successful and what was not. Regarding manufacturers, the majority of their participation in the 'Sugar Reduction Programme' and product reformulation was voluntary and not mandatory (Public Health England (PHE), 2017). This has been criticised by both 'Action on Sugar' and the 'National Food Strategy' team for being unlikely to encourage compliance as there are no direct incentives and without a '*level playing field if they are to start making their products* *healthier' 'competition will simply move in and undercut them'* (Action on sugar, 2022)(Pg 13)(Dimbleby, 2021)(pg.146). It was reported by PHE that between 2015-2019 there was a ~40% reduction in the sugar content of beverages. Although the reduction of the sugar content of beverages is arguably easier in terms of reformulation, much of this success was due to the soft drinks industry levy. This 'levy' incentivised companies to reformulate the sugar content of drinks to avoid penalties. The evidence to date supports the view that voluntary reformulation, rather than mandatory, does not produce substantial enough change(Action on Sugar, 2022; Office for Health Improvement & Disparities, 2022; O'Mara & Vlad, 2023), however with proper policy and regulations, effective reformulation and reduction of the free sugar content of foods is more than possible but likely.

1.1.6. Free sugar guidelines - 10% vs 5%

In 2015, both the WHO and the UK's SACN released guidelines on the recommended intakes for free sugars. The WHO recommended a reduction to 10% TEI for free sugars with the acknowledgement that <5% be a conditional guideline (World Health Organization, 2015). SACN advised that the UK population reduce intakes to <5% TEI of free sugars to be optimal for health (Scientific Advisory Committee on Nutrition, 2015). The reasons for the differences in these guidelines can be considered across key areas of evidence review, global/national focus, and policy applicability.

The WHO guidelines included observational studies, non-randomised trial and those of a shorter duration (World Health Organization, 2015) which differed from some of the inclusion criteria set out by SACN for their report (Scientific Advisory Committee on Nutrition, 2015). Fundamentally the two reports are based on slightly different evidence bases, with the WHO including a broader evidence review and SACN being stricter. The basis of the WHO guidelines came primarily from the review of evidence between the links of free sugar intakes with bodyweight and dental carries (World Health Organization, 2015). SACN considered the same links as the WHO but include the assessment of further evidence from the links of free sugars with cardiovascular disease, colorectal cancer, type 2 diabetes mellitus (T2DM), energy intakes and cardio metabolic outcomes (Public Health England, 2015).

The evidence reviewed by SACN was considered in light of the UK population specifically. The 5% recommendation was put forward because of high intakes of free sugars across all ages. It was suggested that decreasing intakes was appropriate in a nation with high levels of excess body weight (Office for Health Improvement & Disparities, 2024; Public Health England, 2015b). While SACN did not consider the association between free sugars and T2DM sufficient, it did acknowledge its role in the overconsumption of energy, obesity and associated health disorders such as hypertension, tooth decay and coronary heart disease (Public Health England, 2015). In comparison the guidelines produced by the WHO are intended to be relevant to multiple countries, with the scientific reports likely utilised by countries for the development of their own public health policies and programmes (World Health Organization, 2015). To summarise this, the recommendations by the WHO relate to, and are applicable to, multiple countries irrespective of SES status and habits. In comparison the recommendations by SACN focus specifically on the UK and the improvement of the national public health. Therefore, SACN's recommendations can be said to be more tailored to the community in which they are to be utilised, rather than the general recommendations set out by the WHO. The UK guidelines reflect the needs of the UK by considering the current landscape of health conditions and dietary intakes.

In the 2015 report by the WHO, it was stated that the guidelines regarding sugar would be updated in their 2020 programmes (World Health Organization, 2015). The WHO have released information pertaining to sweetener use (World Health Organization, 2023), and defining healthy diets (World Health Organization, 2023), but to date no update of the free sugar guidance has been published. Currently in the UK, I have found no statements that confirm a date of when the information regarding free sugar guidance will be reviewed and updated. It is perhaps of no surprise that issues with dietary guidance being outdated and reviewed are not confined to countries, but also inclusive of global agencies.

1.2. Research background

1.2.1. Health impacts of diet

Diet plays a central role in both our physical and mental wellbeing. Achieving the right balance of essential nutrients, vitamins and minerals is vital for both overall mortality and morbidity (Afshin et al., 2019). The leading cause of global mortality and morbidity is cardiovascular disease (CVD) (Roth et al., 2020); a disease which shows an ever-increasing trend in incidence and prevalence despite having several modifiable risk factors, with diet among them (Roth et al., 2020). Randomised controlled trials (RCT) investigating non-communicable disease (NCD) endpoints have not been realistic, however extensive epidemiological evidence supports a causal relationship between dietary factors (e.g., saturated fat and free sugars) and NCDs (e.g., CVD and cancer)(Afshin et al., 2019; Roth et al., 2020). Diet has a major impact on health in several ways, one of which is bodyweight (Mozaffarian et al., 2011). The consumption of a calorie dense (Stelmach-Mardas et al., 2016), nutrient poor diet contributes to obesity and cardiometabolic disease risk (Anand et al., 2015; Casas et al., 2018). Meanwhile diets high in fibre, fruit and vegetables, lean protein and unsaturated fats contribute to reduced health and cardiovascular risk (Casas et al., 2018).

The consumption of high levels of free sugars specifically have been linked to several adverse health outcomes such as, obesity, poor oral health, anxiety, and CVD (Huang et al., 2023a). Foods high in free sugars such as sweets or sugar-sweetened beverages (SSB's) are most likely to be highly processed and energy dense (S. Gupta et al., 2019). Therefore, the overconsumption of these foods likely increases total energy intakes and potentially bodyweight (Livingstone et al., 2022; Stelmach-Mardas et al., 2016). Linked to this, high sugar intakes may impact appetite via two separate pathways. Firstly, consuming a meal with a high sugar content that create stable blood glucose levels has been association with reduced appetite (Arumugam et al., 2008; Penaforte et al., 2013). Comparatively higher glycaemic index (GI) foods such as SSBs are more likely to increase hunger as they are less likely to stimulate satiety mechanisms leading to greater calorie intakes (Penaforte et al., 2013; S. B. Roberts, 2000). This has been further evidenced in later research showing that postprandial glucose dips lead to increased hunger and energy intakes (Wyatt et al., 2021). Secondly it has been suggested that high sugar consumption may stimulate the dopaminergic reward system, driving up intakes in an addictive like way (Avena et al., 2008; Huang et al., 2023b; Malik & Hu, 2022). These pathways could potentially lead to increased intakes and therefore bodyweight. In addition, research has shown that consumption of energy-dense food, such as those high in fat or sugar also increase total energy intakes, playing a role in appetite regulation (Klos et al., 2023; Poppitt & Prentice, 1996). The consequences of these findings for weight management therapies implicate that interventions of lower fat, sugar, and energy-dense foods may be encouraged for the reduction of bodyweight.

This evidence is given relevance as over the last 20-30 years the prevalence of obesity across the globe has vastly increased (Ng et al., 2014), with the UK seeing rates almost triple since 1980 (Rennie & Jebb, 2005). Further to this, modelling research projects predict the prevalence of morbid obesity to increase by 2035 across the UK (Keaver et al., 2020). This trend in obesity is likely linked to rises in NCDs such as CVD, diabetes and cancer, which is projected to increase further by 2030 (Y. C. Wang et al., 2011).

In addition to NCD's, there is a direct link between free sugar intakes and dental health (Feldens et al., 2022). The frequent consumption of foods and beverages high in sugars promotes tooth decay and cavities via acid producing bacteria that feed on these sugars consequently eroding tooth enamel (Feldens et al., 2022). Poor oral health, separate from dietary intakes, is its own modifiable health factor, as those with poorer oral health are at increased risk of malnutrition (Azzolino et al., 2019). Our diets do not just influence our physical health but also our mental wellbeing (Firth et al., 2020). The connection between the gut-brain axis is increasingly being recognised to significantly contribute to our mental wellbeing (Firth et al., 2020). Recent research has found that diets with greater fruit and vegetable intakes may reduce risk of mental health disorders such as depression and anxiety (Gł et al., 2020). The inverse of increased mental health risk has also been observed for diets higher in ultra-processed foods (Lane et al., 2022) such as those high in free sugars, saturated fats and salt (Monteiro et al., 2019). These findings may be partly explained by variance in socioeconomic circumstance and subsequent health behaviours, however earlier research also supports the independent relationship between unhealthy dietary patterns and depressive symptoms (Jacka et al., 2014).

1.2.2. Current global intakes

Diets that are low in fruit, vegetables, nuts/seeds and whole grains but high in processed meats, free sugars and salt are a health burden across the globe (Afshin et al., 2019; Roth et al., 2020). Around 20-25% of all adult deaths across the world are linked to unbalanced diets (Springmann et al., 2018, 2020; D. D. Wang et al., 2019). When looking at dietary patterns across the globe, no region meets recommendations for healthy and sustainable diets. All areas of the world do not meet intake levels for fruits, vegetables, legumes, nuts and whole grains; with intakes averaging around half of what is recommended (2021 Global Nutrition Report: The State of Global Nutrition, 2021). In addition, the consumption of red and processed meat is on average 377% more than is required (2021 Global Nutrition Report: The State of Global Nutrition, 2021).

As discussed in the section 'health impacts of diet', the dietary impacts on our health is not something that is limited to one corner of the globe or socioeconomic demographic. In addition, intakes of nutrients such as 'free sugars' have been linked to several adverse health outcomes (Huang et al., 2023a). In order to tackle dietary related issues such as obesity, NCD's, malnutrition, maternal and child health, the 2025 Global Nutrition Targets were established by the World Health Organisation (WHO) (2021 Global Nutrition Report: The State of Global Nutrition, 2021). These targets are an essential tool for guiding international and national efforts in the improvement of public health. It is important to consider these in the context of this thesis as it furthers our contextual understanding of community dietary habits and our progress to best nutritional practices. Looking at the 2025 global nutrition targets as set out by the WHO, the UK are on course to meet only one, breastfeeding (2021 Global Nutrition Report: The State of Global Nutrition, 2021). Furthermore, the UK are not on course to fulfil any of the voluntary dietary related NCD targets, including halting the rise and prevalence of; adult obesity; diabetes; raised blood pressure and salt intakes (2021 Global Nutrition Report: The State of Global Nutrition, 2021). In fact, worldwide over 40% of all adults are overweight or obese, ~20% have elevated blood pressure and ~10% have diabetes (2021 Global Nutrition Report: The State of Global Nutrition, 2021). In 2020 the UK was not on track to achieve any of the global nutrition targets (Global Nutrition report, 2020) which presents as a disappointing statement for both international and national efforts.

In the UK's most recent reports by the NDNS, we can see in all age groups intakes of free sugars and saturated fat exceeded UK recommendations (Public Health England, 2020b), whereas fibre intakes in all ages did not meet requirements. Looking at sugar specifically, initial reductions in total energy intakes of free sugars were seen across the 10 years from 11.8% (TEI) in 2008 to 9.9% (TEI) 2019, (Public health England, 2020a). In the latest report

(Year 12) of the NDNS programme, it was found that intakes of free sugars for the period October 2019 – March 2020, increased to 10.5% in adults age 19-64 years(Public Health England, 2021). This shows there has been a stagnation in the rate of reduction of free sugar intakes. This combined with the UK government not renewing or replacing it's 'Sugar Reduction Programme', and the fact we are still far from achieving the recommended <5% free sugar intake guidelines (Scientific Advisory Committee on Nutrition, 2015) highlights the need for more work to be done in this area. Considering the poor progress to Nutrition goals as set out by the WHO, it is disappointing this issue is not brought to the forefront of adequately planned government led strategies to improve dietary practices and therefore potentially health.

1.2.3. Sustainability

In sustainable healthful diets, increased consumption of fruits, vegetables, legumes, nuts, whole grains and plant-based food are emphasised, while consumption of process meat, free sugars and salt is limited (Kumanyika et al., 2020; Steenson & Buttriss, 2021). It is estimated that adoption of these dietary patterns could reduce both gas emissions and land use by 20-50% (Steenson & Buttriss, 2021). In addition to having a detrimental effect on our health, poor dietary profiles are both costly and bad for the environment. It was estimated that in 2018 due to global food demand, loss and waste, around 17.2 billion tonnes of greenhouse gas emissions were generated (2021 Global Nutrition Report: The State of Global Nutrition, 2021). The majority of this was contributed from animal source foods (~56%), especially beef and lamb production (2021 Global Nutrition Report: The State of Global Nutrition, 2021). What is little known is the contribution from sugar production and its environmental impact. The ever-increasing demand for free sugar has led to high water consumption, pollution and degradation of soil (WWF, 2005). In the WWF's report on 'Action for Sustainable Sugar', it is estimated soil loss can range between 3-10% from the harvest of sugar cane or beet sugar respectively (WWF, 2005). In a global modelling study, it was found that FBDG reflective of healthy eating guidelines such as reducing red meat and sugar intakes, resulted in diets closer to sustainability criteria, leading to potential reductions in environmental impact. However, not all national recommendations reflect this by containing limits on animal-based foods (Springmann et al., 2018b). In 2018 food related greenhouse gas emissions exceeded limits set by the Paris Climate agreement by around three-quarters

(74%) (2021 Global Nutrition Report: The State of Global Nutrition, 2021). No region globally is set to achieve sustainable development goals in relation to the environmental impacts of the food system. Therefore, it could be said the current dietary patterns are unsustainable, and if changes do not occur, the resulting emission levels will only increase. While adherence to vegetarian and vegan diets may enhance positive environmental impact, they are perhaps less likely to be widely adopted. Therefore, adherence to government guidelines such as the UK's Eatwell Guide is perhaps a more realistic recommendation in enhancing both the environment and health of the nation (Steenson & Buttriss, 2020, 2021).

1.2.4. Financial impacts

In the United Kingdom, there is a steadily rising percentage of adults and children who struggle with being overweight or obese. This growing tendency has financial repercussions for the country in addition to taking a toll on public health. It was estimated that the National Health Service (NHS) spent £6.1 billion on costs associated with the health problems brought on by being overweight in 2014–2015. Furthermore, the government estimated that the wider cost to society surmounted a sizeable £27 billion. These numbers are predicted to rise even further; estimates suggest that by 2050, societal costs might reach £49 billion, while NHS costs could reach a staggering £9.7 billion (Public Health England, 2017).

1.2.5. Adherence

Dietary profiles that adhere to recommendations have been linked to improvements both in diet related disease mortality and environmental sustainability (2021 Global Nutrition Report: The State of Global Nutrition, 2021).

In the UK Biobank cohort of >100,000 individuals, higher adherence to international WHO dietary recommendations was associated with a decreased mortality risk; bodyfat; waist circumference and low-density lipoprotein (LDL) cholesterol (Kebbe et al., 2021). Less than 10% of the cohort met 3 or more recommendations, with the majority achieving one (38.5%) or none (29.7%) of the recommendations. This low adherence to dietary recommendations is found in both high-, low- and middle-income countries with 40% found to not adhere to food based dietary guidelines (Leme et al., 2021).

In the UK Yau observed that from the period 1986-2012, adherence to dietary guidelines had improved and considered that adherence was now 'low to moderate' on average (Yau et al., 2019a). A more recent study in 2020 (Scheelbeek et al., 2020) reported that only 0.1% of the UK population were adhering to all nine of the Eatwell Guide recommendations, with the largest proportion (44%) adhering to 3-4 of the recommendations. The recommendations adhered to the least included those for fibre intake, oily fish and sugar, with only 7.2%, 16.8% and 24.2% of the population meeting targets respectively (Scheelbeek et al., 2020).

It is evident that both global (Batis et al., 2012; den Braver et al., 2020; Leme et al., 2021) and UK (Culliford et al., 2023; Kebbe et al., 2021) adherence to dietary recommendations is poor. Therefore, understanding both the barriers and facilitators to change this is vital. Barriers and facilitators may often be the same factor but reported as inverse of each other (Deslippe et al., 2023a). For example, a positive attitude may facilitate change whereas the inverse, a negative attitude, presents as more of a barrier (Deslippe et al., 2023a). There have been many studies investigating these factors linked to dietary change and adherence (Mathes et al., 2014). However broadly they can be broken into factors such as (Cradock et al., 2021; Deslippe et al., 2023; Mathes et al., 2014; World Health Organization, 2003):

- Social and economic
- Therapy related or intervention.
- Patient or individual
- Health care system
- Conditional related factors
- Environmental

From the aforementioned evidence it is clear that there are many interpersonal and environmental factors affecting adherence to dietary factors. To see sustained and beneficial change, adherence to dietary recommendations needs to be long-term rather than short-term. Few studies have investigated adherence and time specifically, but we know that people do not adhere to either national dietary guidelines or targeted interventions for weight loss (Lemstra et al., 2016). In studies investigating dietary adherence, a comprehensive set of advice is needed for long-term improvement (Quintana-Navarro et al.,

2020) however, regression to previous dietary habits is still a risk, with more large-scale long-term trials needed to assess this (Downer et al., 2016).

1.2.6. Sweeteners

Sweeteners can be broadly split into two categories, nutritive and non-nutritive. Nutritive sweeteners or 'carbohydrate sweeteners' are caloric substitutes for sucrose that are generally more acceptable in taste and texture than their non-nutritive counterparts. Examples of nutritive sweeteners include, Sorbitol, Xylitol and Maltitol to name a few. Non-nutritive sweeteners, also called 'artificial sweeteners' or 'low-calorie sweeteners', are often non-caloric and much sweeter than sucrose. Therefore, non-nutritive sweeteners can often be added to foods without altering formulations or adding calories. A few examples of non-nutritive sweeteners include Aspartame, Acesulfame-k and Sucralose (Jacob et al., 2021). The potential benefits to using these sucrose substitutes includes factors such as bodyweight management (Harrold et al., 2024; Mathur & Bakshi, 2024; Rogers & Appleton, 2020), glycaemic control (Mathur & Bakshi, 2024; Zhang et al., 2023) and promoting oral health (Hayes, 2001). However, the use of non-nutritive sweeteners in the diet has been controversial. Research is inconclusive but some reports have suggested that non-nutritive sweeteners may not be beneficial for weight management (World Health Organization, 2023), and in fact increase the risk of adverse health effects (Azad et al., 2017; Debras et al., 2022; Liauchonak et al., 2019) .

In the UK and aboard, agencies such as the European Food Safety Authority (EFSA) have published guidelines for set acceptable daily intakes (ADI) levels for all approved market sweeteners (European Commission, 2021). These ADI guidelines represent a maximum daily limit for the consumption of non-nutritive sweeteners and for the majority of people consumption of NNS is far below the recommended levels (Martyn et al., 2018). Despite these products being approved for consumption, public perception of non-nutritive sweeteners, especially Aspartame is often poor (Farhat et al., 2021) In a recent publication by the WHO (World Health Organization, 2023), it was recommended that non-sugar sweeteners not be used for weight control or reducing risk of NCDs. Recently data from a large trial (n=493) investigating non-nutritive sweeteners vs water on weight management across 52 weeks contradicted this finding (Harrold et al., 2024). The authors report that weight loss occurred in both groups with improvements to most biomarkers and sugar consumption (Harrold et al., 2024). However, there was no differences between the two groups and weight loss did not reach clinical significance but was statistically significant (Harrold et al., 2024). It has been suggested that the differences between these two positions on non-nutritive sweeteners and body weight is due to reports from observational studies outlining a negative relationship to NNS, and RCT studies which shown neutral or beneficial effects of NNS (Harrold et al., 2024; Normand et al., 2021; Rogers & Appleton, 2020).

Overall and in my opinion, the argument for discontinuing the use of non-nutritive sweeteners is not yet supported soundly enough in literature. Robust RCT's have shown the potential benefits of using NNS without adverse effects. We can only wait until evidence from multiple long term RCT's is sufficient enough to take a stance on these substances. Like all dietary practices and aids, moderation, review, and proper use is vital.

1.2.7. Statement – the problem

It is evident that dietary intakes, especially across the western world, need to change in order to improve both our health and environment. We know that the dietary recommendations themselves are beneficial if followed correctly; the problem is that people are unable to adhere to them, and we need to know why, and how to improve this.

Looking at the most recent reports by the National Diet and Nutrition Survey (NDNS) in the UK we can see in all age groups intakes of free sugars and saturated fat exceeded UK recommendations (Public Health England, 2020b), whereas fibre intakes in all ages did not meet requirements. Looking at sugar specifically, although intakes have reduced across the past 10 years (11.8% in 2008), current intakes of 9.9% (2019) total energy intakes of free sugars (Public health England, 2020a) are still far from the <5% recommendation set out by SACN for optimal health (Scientific Advisory Committee on Nutrition, 2015).

1.3. Dietary guidelines overview

The purpose of dietary guidelines is to recommend food and drinks that meet nutrient demands for the promotion of health and prevention of disease. Broadly speaking, and for the context of this review, dietary advice is made up of three types of information, nutrient based, food based, and swap based. These often overlap to form many of the international FBDG we know today and are defined below.

1.3.1. Definition of nutrient information

In defining nutrient based advice, the example from UK terminology is discussed. Reference nutrient intakes are a set of nutrient guidelines which provide an estimate of the amount of each nutrient required to meet the nutrition needs of the population and prevent malnutrition. Reference nutrient intakes (RNI) is the term used in the UK whereas other terms such as recommended dietary allowances, or estimated daily intake may be used internationally (Department of Health, 1991). Information on RNI's can be present on the back of packaging along with nutrient tables, and coloured nutritional labels (traffic light system). Nutritional labels provide the consumer with information for making healthier choices (NHS, 2022). Although nutrient tables on the back of packaging are mandatory, the traffic light system is a helpful visual tool to compare a quick summary of whether the product meets nutrient recommendations (Franckle et al., 2018; NHS, 2022).

> The traffic light system for food labelling outlines if a product is high (red), medium (amber) or low (green) in nutrients such as salt, sugar, fat and saturated fat. It may also provide information on the number of calories per serving or per 100g. A red colour explains this product is high in these nutrients and should be consumed less often or in small amounts. Amber foods contain moderate amounts of the nutrients and should be consumed some of the time. Green foods indicate the product is healthy and should be the most consumed group (NHS, 2022).

In addition to RNI's, ingredient lists also provide nutrient level information by listing all the individual foods or additives within a product. This can include both advice regarding hidden free sugars e.g., 'pureed apple', and allergy information e.g., celery, with allergy information shown in bold for the most common allergies (GOV.UK, 2023). In summary nutrient level information refers to the quantitative or numerical content of the nutrients within foods and all ingredients included in the formulation of products.

It is worth commenting that there can be some critique for the labelling of sugars within the UK. Currently guidelines for health are focused on reducing free sugar intakes to <5% TEI. Despite this, there is no labelling for 'free sugars' specifically. To evaluate packaged products which may contain 'free sugars' we need to assess both the nutritional content of 'total sugars' and 'Of which sugars' in combination with ingredients lists. This makes the process of assessing the free sugar content of our foods by nutrient information alone challenging. In addition, not all foods are labelled, and advertisers can freely use the term ‘no added sugar’ which deceptively can make some products appear ‘healthier’ or at least lower in sugar content that is actually true.

1.3.2. Definition of food information

Food based information refers to advice where recommendations are provided in whole foods not nutrients. These food-based recommendations are often based on the nutritional considerations of food content and seek to disseminate complex nutrient information into easily understood practical food-based messages. For example, instead of outlining advice to reduce intakes of products that are *‘high in sugar – 22.5 g or more of total sugar per 100g*’ it would be recommended to reduce intakes of food and drinks such as ‘*cakes, chocolate, packaged sauces or fruit juices* ’(NHS, 2018). This is perhaps the most familiar type of advice to the consumer as it forms the well-known food based dietary guidelines produced across the globe (Herforth et al., 2019).

1.3.3. Definition of swap information

Swap based information is presented in this thesis as a separate category to food information due to the behavioural differences needed to adhere to either a reduction of a food, or a substitute for that food item. Information on dietary swaps still references information on whole foods and drinks, however instead of calling for the reduction, substitutions are advised. This advice is again based on the nutritional content of the original and new substituted food. Swap based messages could include substitution to either increase or decrease target dietary nutrients however, swaps that encourage reductions are most commonly used and outlined in national dietary recommendations such as the United Kingdoms ‘Eatwell guide’ (Public Health England, 2016b). For example, a food-based message as outlined before would advise ‘*reduce intakes of biscuits’* whereas a swap-based messages would encourage *‘biscuits – swap for oatcakes, oat biscuits, or unsalted rice cakes*’(NHS, 2018). These messages may also suggest the use of products such as low-calorie sweeteners, which aim to retain the sweet taste while achieving reductions in target nutrients such as sugar or energy density in this example.

1.4. Current UK free sugar reducing advice

In an earlier section, we were introduced to the UK's Eatwell Guide (Public Health England, 2016b), discussing both the origins of the UK's dietary guidance and the reformulation of the current advice (Public Health England, 2016a). At present access to the UK's Eatwell Guide can be achieved on both the government (Public Health England, 2016b) and NHS websites (NHS, 2018). In addition to providing a visual overview of the Eatwell Plate, there is further guidance on 'How to cut down on sugar in your diet' available to the public (NHS, 2018).

1.4.1. Free sugar nutrient information

This guidance includes nutrient information on '*sugar's many guises'* (NHS,2018), regarding the multiple ways added sugar can be listed as ingredients e.g. sucrose, fruit juice, corn syrup. In addition to what to look out for in terms of products being both 'high in sugar – 22.5g or more of total sugar per 100g' or 'low in sugar – 5g or less of total sugar per 100g'(NHS, 2018).

1.4.2. Free sugar food information

Further on from the nutrient level advice, information on the types of foods likely to be high or low in free sugars are included under mealtime headings including 'Breakfast, main meals, snacks, drinks and dessert' and include messages such as *'Condiments and sauces such as ketchup can have as much as 23g of sugar in 100g – roughly half a teaspoon per serving'* informing individuals that food items such as ketchup are likely to be high in sugars (NHS, 2018).

1.4.3. Free sugar swap information

In addition to this advice on food are suggestions for food swaps e.g., '*Try switching to lower-sugar cereals or those with no added sugar, such as: plain wheat biscuit cereal, plain porridge…'.* There is also education around eating habits and gradually reducing sugar intakes using helpful tips such as '*you could eat sugary cereals and plain cereals on alternate days, or mix both in the same bowl'* (NHS, 2018). The NHS also provides advise on the use and safety of foods substitutes such as low-calorie sweeteners (NHS, 2019a). This includes again how to identify them on ingredients lists e.g., sorbitol and xylitol; what products they are likely found in e.g., drinks and cakes, as well as their safety and links to health (NHS, 2019a).

1.4.4. *Summary statement*

Despite the UK's dietary advice being comprehensive (Herforth et al., 2019; NHS, 2018; Public Health England, 2016a), there have been few studies investigating the efficacy of messages to enact behaviour change in the real-world. In addition, their messaging regarding sweetener use is lacking as it states no harm but offers no utilisation of products to help with reducing sugar intakes. Comparatively, the organisation Diabetes UK provides a comprehensive list and guideline on the identification, utilisation, and safety of sweetener products (Diabetes UK, n.d.-a).

1.5. Review of nutrient, food and swap studies

Due to a lack of literature in testing specifically 'free sugar' reducing advice on free sugar intakes the inclusion of RCTs testing interventions to reduce 'sugar' or 'sugar sweetened beverages' is included in this review. To assess the effectiveness of the current literature of nutrient, food and swap sugar reductions messages on reducing intakes in adults the following process was followed. Using published methodology for a systematic approach to literature searches (Bramer et al., 2018) the following steps were taken. This process was chosen to provide a comprehensive overview of the available literature. Additional articles not present in the systematic search were also included in the discussion of literature where relevant. These articles were found from the researchers previous reading around the topic and the field of sugar interventions and dietary change.

1.5.1. Review steps

Step 1, aim of search and search question: Assess the effectiveness of utilising nutrient, food and swap sugar reduction interventions, primarily in adults.

Step 2, relevant articles to be identified: Articles considered should only be of RCT design, have a clear distinction for testing either nutrient, nutrient and food, or nutrient, food and swap level interventions as outlined earlier in this chapter. As the focus of this research is within an adult population, included articles will primarily be chosen using adult populations, with older or younger age groups only referenced in a further lack of evidence. Articles will be limited to studies conducted in healthy human individuals, families or groups.

Step 3, database selected: PUBMED was chosen as a suitable database to conduct searches as it offers a comprehensive reliable database on literature related to the aim of this search.

PUBMED also benefits from being freely accessible and allows for searches using MeSh Indexing and advanced terms.

Step 4, search terms selected: A simply worded search strategy for this review of evidence was adopted to capture relevant information on reducing sugar interventions. Therefore, the search terms 'sugar' AND 'reduce' were combined for inclusion in either titles of abstracts of systematic reviews and/or meta-analyses. By refining the systematic reviews and/or meta-analyses, a broad level of evidence representing the literature as whole could be gained. Further to this, an additional term, 'intervention' was added for when searching for more recent RCTs containing sugar reduction messages that had not yet been included in published systematic reviews and meta-analyses.

Step 5, searches conducted: After the selection of search terms and the database, two searches were completed. All information was extracted and recorded using excel with a summary of included articles outlined in the text. Due to PUBMED lacking the technical functionality to extract articles abstract data into excel, the online platform PubData2XL (Isaak, 2016) was utilised for the extraction of articles abstracts used in the screening of articles.

Articles were chosen in both searches for full title screening if they were assessed to include a dietary/behavioural intervention, which included assessments or reporting of results for intakes of, or prospective intakes of; sugar; free sugar; added sugar; sugar sweetened beverages; or sweet foods. Where interventions did not include assessments of these outcomes, articles were excluded for full text review.

***Step** 6*, all relevant studies as described below were read and assessed for inclusion. Only those that could be categorised as either nutrient, food or swap interventions were included. Where interventions were too integrated, not detailed enough in intervention delivery, or did not include sugar/SSB/sweet food outcomes they were excluded. Descriptions of the relevant literature and summaries for each section are provided.

Search one: PUBMED was searched on the 05/09/2024 for any systematic reviews or meta-analyses containing with words 'Sugar' AND 'Reduce' in their title or abstracts.

Syntax used: (Sugar[Title/Abstract]) AND (Reduce[Title/Abstract])

Of the 172 articles found, 14 full papers were read to aid in the discovery of RCT's utilizing nutrient, food and swap-based interventions (Avery et al., 2015; Chambers et al., 2015; Dibay Moghadam et al., 2020; Hashem et al., 2019; Rahman et al., 2018; Scapin et al., 2021; Shagiwal et al., 2020; Vargas-Garcia et al., 2015, 2017; von Philipsborn et al., 2019; Von Philipsborn et al., 2020; Al Rawahi et al., 2017; Azhar Hilmy et al., 2024; Ezike & Da Silva, 2023). Review studies (Al Rawahi et al., 2017; Avery et al., 2015; Ezike & Da Silva, 2023; Rahman et al., 2018; Shagiwal et al., 2020; Von Philipsborn et al., 2019) were checked, but mostly did not contribute to findings due the focus on childhood or adolescent sugar/SSB intakes. Where limited evidence was found, additional non-RCT and non-sugar or SSB based studies were included.

Search two: PUBMED was further searched on 05/09/2024 for any recent RCT trials containing the words 'Sugar' AND 'Reduce' AND 'Intervention' in their title or abstracts.

Syntax used: ((Sugar[Title/Abstract]) AND (Reduce[Title/Abstract])) AND (Intervention[Title/Abstract])

Of the 149 articles found, 13 were selected for full text review. Of these only a further 5 studies were identified and included (Falbe et al., 2023; Franckle et al., 2018; Judah et al., 2020; Mason et al., 2021; Woo Baidal et al., 2021). The 8 studies excluded at full text review were due to interventions used being combined across nutrient, food and swap categories (N = 4), only behavioural intent measured (N= 1), effects on direct intakes not reported (N = 1) or were already identified in earlier systematic review searches (search one) (N = 2).

1.5.2. Nutrient interventions

Nutrient focused interventions may refer to both individual and government led strategies. Studies specific to sugar and SSB nutrient targets include RCT investigations of sugar warning labels on choice (Falbe et al., 2023), sugar warning and content information texts on consumption (Woo Baidal et al., 2021) food labelling (Borgmeier & Westenhoefer, 2009; Cecchini & Warin, 2016; Ni Mhurchu et al., 2018). and systematic review and meta-analysis of sugar labelling formats (Scapin et al., 2021). Non-specific sugar studies include government strategies such as the UK's 'Salt Reduction Programme', which as previously discussed showed some success. Nutrient targeted interventions are those that have been implemented or tested with the interventions directly rooted in nutrient specific led policies or actions.

In 2009, a RCT by Borgmeier and Westenhoefer, investigated the impact of different food labelling formats on food choice in 420 adult consumers. Individuals were first exposed to one of five types of labelling format and then asked to identify the healthier food options, and then in a second task to select food portions for a day's intake. There were significant differences between those provided no label information (least decisions correct) and traffic light labelling (most decisions correct), with 20.2 ± 3.2, and 24.8 ± 2.4 products correctly identified as being healthy respectively (Borgmeier & Westenhoefer, 2009). Despite this evidencing that the different labelling formats directly impacted consumer understanding, there was no significant difference between the experimental groups on their estimated food consumption in the second task. The authors concluded that although consumer understanding can be significantly impacted by food labelling, it is unlikely to impact consumer intake behaviours (Borgmeier & Westenhoefer, 2009). It is important to note that the participant sample in this RCT was highly educated with prior knowledge not accounted for. Moreover, the low number of foods used (foods = 78) with the activity analysed is perhaps not as reflective for real world use in which thousands of foods are on offer.

A later systematic review by Cecchini and Warin 2016 contradicted these earlier conclusions. Despite some limitation in the comparability of the food labelling and study type, they found that food labelling may impact consumer choice (Cecchini & Warin, 2016). Results were not statistically significant, but in interventions with food labelling, the number of individuals selecting healthier options increased by 17.95% (CI: +11.24% to +24.66%), alongside decreases in calorie intake/choice by 3.59% (CI -8.90% to +1.72) (Cecchini & Warin, 2016). Their findings suggest nutrition labelling, especially traffic light labels, could be an effective strategy in guiding consumers choice and healthier product selection (Cecchini & Warin, 2016). They do however criticise the amount of evidence currently available with calls for more research to be undertaken within the area of nutrition labelling and consumer impact. As such, the review itself is limited in regard to the quality of the studies used and the comparative labelling clusters utilised for analyses. It does however benefit from only presenting data from randomised controlled trials with several studies included. As such although the RCT trials utilised may not all be of the highest quality the findings presented across the review as a whole can likely be trusted.

Further evidence investigating the use of labels and healthier food choice was completed by Ni Mhurchu in 2018. In a four-week RCT into the influence of nutrition labels and food purchases it was observed that labels were viewed 23% of the time, with decreasing frequency across the intervention (Ni Mhurchu et al., 2018). Where participants viewed labels and then purchased products, the food item was significantly healthier than where labels were viewed but not purchased, with a mean difference in the nutrient profile score of −0.90 (95% CI -1.54 to −0.26). Although the findings here align with those in presented in the systematic review by Cecchini & Warin, 2016, some caution must be applied. These results arose from post-hoc analyses, and therefore do not benefit from pre-specified hypotheses, with findings at risk of arising from data dredging. Despite the use of an RCT design, the results from this study have to be viewed as less reliable than data from RCT's with reliable pre specified hypotheses. The authors report there was a positively significant association between label usage and healthier items purchased, concluding that nutrition labels may influence the consumers who use them (Ni Mhurchu et al., 2018).

A recent meta-analysis (Shangguan et al., 2019) into the effects of food labelling on consumer dietary behaviours and industry practises reported positive nutritional outcomes linked to food labelling. Out of the 60 papers included the following observations of consumers from food labelling were reported; intakes of energy, total fat and unhealthy dietary options decreased by 6.6%, 10.6% and 13.0% respectively. Whereas consumer intakes of vegetables consumption increased by 13.5%. The authors also reported that industry decreased the content of sodium and artificial trans-fat in their products by 8.9% and 64.3% respectively (Shangguan et al., 2019). This provides evidence in the support for nutrient guidelines for both consumers and industry. Despite all the studies included in the review being interventional, caution over the quality and heterogenous nature must be recommended when viewing the results. In addition, despite being published in 2019, literature searches were performed in 2015, with no update to the searches completed. Although heterogeneity is natural in part due to the wide variety of food labelling option available, more is research needed into the assessment of the endpoint effects of food labelling such as disease risk (Shangguan et al., 2019).

The effect of beverage warning labels, sugar content information or attention control text messages on SSB consumption was tested in an RCT of 262 pregnant women and mothers (Woo Baidal et al., 2021). The graphic health warning contained messages specifically regarding sugary drinks and problems for the mother and baby; the sugar content text provided information of sugar content of certain foods and drinks (e.g., donuts) finally, the attention control message contained general information regarding infant care. After 1 month there was no significant difference between the groups in SSB consumption. In the health warning, sugar content, and attention control groups, SSB consumption significantly reduced by 65.50kcal, 79.96kcal and 45.81kcal respectively. Further sensitivity analyses that accounted for outliers, found that the graphic health warning message significantly reduced SSB consumption by 28kcal daily compared to the control. Overall, Woo Baidal. (2021) found no intervention effects in their main or secondary analyses, however they state that text messaging of SSB warning is a potentially useful method of aiding additional public interventions for reducing intakes, but should not be expected to make substantial differences to intakes. Furthermore, an obvious limitation for the applicability of this research is the target population. Even with the target demographic being pregnant women and mothers, the majority of the participants were Hispanic and Latino. In the context of this thesis the findings here when viewed alongside other RCT's and systematic reviews diminish this effect. This is due to the fact that Caucasian populations are commonly well supported in research.

In 2021, a systematic review and meta-analysis into the influence of sugar labelling formats on consumer understanding and sugar content of food choices was published (Scapin et al., 2021). Of the 23 RCT trials included in the meta-analysis, the authors found 'high in sugar' labelling with interpretative texts and warning signs more effectively increasing consumer understanding regarding sugar content. Comparatively the most effective packaging time for influencing consumers to pick 'low in sugar' products was visualisations of sugar content using teaspoons, health warning messages and signs (Scapin et al., 2021). They concluded that interpretative food labelling formats such as those indicating if products are higher in sugar, compared to only numerical data, were more helpful in the promotion of lower sugar food choices. This review can be subject to the bias inherent in studying the nature of food labelling, by not being able to account for the effect other nutrients have on choice.

However, the methodological integrity and reporting of this research enhance the validity of the findings communicated by the authors.

In a more recent publication (Falbe et al., 2023), the impact of sugar warning labels on hypothetical choice of high-added sugar items in a US sample of 15,496 individual was investigated. The control group had experienced restaurant menus with no added-sugar warning label, whereas the intervention group received menus with warning labels for high added sugar content. Warning labels significantly reduced the probability of ordering ≥1 high added sugar item by 2.2%, however only 47% of participants noticed these nutrition labels. When analysing just those that noticed sugar warning labels, added sugar was significantly reduced by 4.9 grams compared to the control group. The concluded that warning labels should be designed to be noticed, and that they could contribute to reduction in ordering of high sugar items. As this study only looked at hypothetical choice, the results cannot be extrapolated to actual behaviour. Results must only be considered in terms of giving an indication of what the behaviour could be, rather than actual outcomes.

Overall food labelling as a nutritional intervention to impact dietary choice can directly impact the consumer in a positive manner to make healthier choices, when the individual has both understanding of the labelling and is proactive in making dietary choices. In addition, front of pack labels are a useful nutrition intervention with interpretative colour-coded information and graded designs likely to be the most effective in both understanding and therefore dietary changes (Cecchini & Warin, 2016; Egnell et al., 2018; Pettigrew et al., 2022; Scapin et al., 2021; Shangguan et al., 2019). In addition, it is clear that industry formulations with specific nutrient guidelines can potentially aid in dietary and health changes at the national level (He, Brinsden, et al., 2014; He, Pombo-Rodrigues, et al., 2014). Moreover, it is encouraging that further investigation into specific nutrients remains a focussed interest for researchers (Payne Riches et al., 2019). The findings outline the need for comprehensive and effective policies and guidance that address healthy food affordability, availability, as well as interventions that can help consumers improve their nutrition knowledge to make knowledgeable and healthier choices.

1.5.3. Food based interventions

Food based interventions are concerned not just with the nutrients in the diet, but with encouraging the increase of specific food groups, such as fruits and vegetables, or reductions in foods such as SSB's. The evidence for the effectiveness for food messages alone is limited, however some research has been done into specific foods portion size advice (Tapsell et al., 2014), sugar content of SSBs items (Mason et al., 2021), restrictive (Ebbeling et al., 2012) or non-restrictive food messaging (Lapointe et al., 2009) and dietary feedback text messaging (Kerr et al., 2016)

The connecting Health and Technology study (Kerr et al., 2016) aimed to improve dietary intakes of junk food, SSBs, fruit and vegetables in 247 young adults across a 6-month intervention period. Individuals were randomised to three intervention arms and received either: dietary feedback and weekly texts; dietary feedback only; or control group. At 6 months, servings of SSB in the feedback only group significantly reduced from baseline (-0.2 ± 0.1 servings p=0.02) however the between group difference in mean change relative to the control group was non-significant. Female participants significantly reduced servings of SSB from baseline at 6 months (-0.3 ± 0.1 p<0.01) with the mean change between the feedback only group and control also significant -0.2(95%CI -0.4,-0.01, p=0.04). Male participants had non-significant SSB change in both pre-post and between group tests. These findings could be attributable to the higher proportion of females to males within the study. The higher number of female participants may have provided greater sensitivity of small changes within the group. The authors conclude that mobile dietary feedback has potential for health promotion interventions in the future, while acknowledging the limitation that some analyses may not have been sensitive enough to detect small but meaningful changes (Kerr et al., 2016)

Mason et al. (2021), designed a brief motivational intervention designed to reduce SSB consumption in high consumers of SSBs within a workplace setting where SSBs were banned. A total of 214 individuals were randomised to receive the brief intervention (BI) or no intervention (control). The BI included a session where a health professional visually demonstrated the quantity of sugar in SSBs commonly consumed by each individual, using sugar cubes. Information on the health benefits for reducing sugar intake was also included. This study is categorised a food level intervention as it provided data to participants of the content of SSBs high in sugar, rather than focusing on nutrient labelling and content in general. Participants who recorded larger baseline SSB cravings (SD +1) had significantly smaller reductions in SSB consumption at 6 months in comparison to individuals with smaller baseline SSB cravings (SD -1), 2.5 oz vs 22.5 oz ($p<0.01$) respectively. Additionally, participants with the strongest SSB cravings in the brief intervention group had significantly larger reductions in daily SSB consumption than individuals outside of this category, -19.2 oz, and -2.5 oz ($p<0.001$ respectively) (Mason et al., 2021). This study provides supporting evidence for the use of multi-level intervention policies in reducing SSB consumption, as individuals with stronger cravings reported greater reductions in the sales ban and BI group. The design of this intervention may have been improved by the allocation of the control group within a separate company without a SSB's sales ban and is something the authors acknowledge themselves (Mason et al., 2021). It is perhaps artificial to measure an individual reduction in consumption of SSB within a context of there lack of availability. Moreover, the intake of data was reported using a beverage intake questionnaire with participants self-reporting intakes. No commentary regarding the blinding of participants was included in this study. Therefore, the fact that participants could have known the purpose of the research within the context of being asked to reduce intakes at a workplace with a SSB ban could introduce a level of bias. I would recommend that although these results presented above are methodologically sound, the wider context of their limitations be considered.

A RCT testing the effect of increasing vegetable consumption on weight loss included a variable message on portion size (Tapsell et al., 2014). This study was included in this review as it provided a clear description of a food-based intervention and its outcome. A total of 120 overweight adults were asked to follow two energy deficient diets consuming 5 servings of fruit and vegetables per day. Participants were split into the two groups of control vs comparator, with the only difference in the advice provided in what was considered a portion of fruit or vegetables; 0.5 vs 1.0 cup cooked; 1 vs 2.0 cups of raw, respectively (Tapsell et al., 2014). After 12 months, the comparator group consumed significantly more energy (percentage) intake from vegetables than the control ($p=0.02$) (Tapsell et al., 2014).

In another study, restrictive and non-restrictive messaging was tested (Lapointe et al., 2009). A total of 68 overweight and postmenopausal women were randomised across two groups for 6 months. The non-restrictive messaging group (HFIV) were asked to increase fruit and vegetable intakes, with advice centred on the inclusion of these foods' items with no advice on restricting fat provided. On the other hand, the restrictive messaging group (LOFAT) had advice provided on decreasing their intake of high fat foods and how to identify them. The authors state '*both dietary approaches were based on food habits without goals for energy restriction'* (Lapointe et al., 2009)(pg.195). In the comparison to baseline intakes both groups saw significant decreases in energy intakes (HIFV, −0.3±0.2 kcal/g; LOFAT, −0.3±0.3 kcal/g; p<0.0001), (Lapointe et al., 2009) respectively.

Although the two studies above (Lapointe et al., 2009; Tapsell et al., 2014) do not include a message on sugar intakes specifically. They provide an indication of the effect messages regarding portion sizes and restrictive messages can have. Successful dietary change in my opinion does not happen in isolation, with many techniques such as portion size reduction required to be effective. Moreover, there are many ways to present messages such as restrictive and non-restrictive messaging. The inclusion of these studies can be critiqued due to their subject matter however, they are arguably included in this section of 'food-based interventions' due to the clarity of the interventions tested.

The evidence above shows that food-based messaging may be an effective recommendation type for enacting dietary changes. Methods found to enact dietary change included dietary feedback (Kerr et al., 2016), visual demonstrations of intakes (Mason et al., 2021) and increased portion size food suggestions (Tapsell et al., 2014). In addition, one study investigating both restrictive and non-restrictive food messages found benefits to both (Lapointe et al., 2019). Due to limited literature investigating food-based interventions alone a consensus on its effectiveness is difficult to conclude, however initial investigations into food-based guidance appear positive.

1.5.4. Swap based interventions.

Food swaps and substitutions have been thought to be a helpful tool in improving dietary intakes despite limited investigations into their effectiveness. Studies of note have investigated swap-based interventions in terms of restrictive messages (Ebbeling et al., 2012), beverage substitution (Judah et al., 2020; Tate et al., 2012), product reformulation

(Hashem et al., 2019), food purchases (Forwood et al., 2015; Koutoukidis et al., 2019) and following the Change4life campaign (Lamport et al., 2022).

A RCT investigating the consumption of sugar-sweetened beverages and weight gain tested an intervention using messages for restricting purchases of SSB's and utilising the provision of noncaloric beverages in 224 obese adolescents (Ebbeling et al., 2012). Although this study was conducted in an adolescent population and could be criticised for inclusion in this review. It was included due to the clear nature of the intervention being a dietary substitution/swap. The intervention focussed on displacing SSBs, with written instructions to drink the provided noncaloric beverages and not buy SSBs (Ebbeling et al., 2012). Baseline intakes in both the control and experimental groups was 1.7 servings of SSBs per day. At 1 year, intake in the experimental group was 0.2±0.4 servings/day whereas the control was 0.9±1.1 servings/day, however at 2 years the experiment group was still lower at 0.4*±0.5* servings/day Vs the control 0.8±0.8 servings/day. The subsequent body mass index (BMI) increase was smaller in the experimental group at year 1, but there was no difference by year 2 (Ebbeling et al., 2012).

Data from the Choose Healthy Option Consciously Everyday (CHOICE) trial first reported by Tate et al. (2012) was further analysed and reported by Piernas et al. (2013). In this three arm 6-month RCT differences in dietary consumption patterns and energy intakes were investigated with individuals assigned to caloric substitution beverage advice. A total of 210 individuals from the CHOICE trial (Tate et al., 2012) were included in this analysis (Piernas et al., 2013). Individuals were assigned to receive a message to substitute ≥2 servings/d of caloric sweetened beverages with either water (water group, n = 106) or diet beverages (DB group, n = 104). The methodology for accounting for estimates of low calories sweetener consumption can be critiqued and potentially responsible for a lack of findings. Low calorie sweetener intakes were approximate across items recorded due to a lack of information in the database used. Moreover, groups of foods were aggregated which could have reduced the sensitivity of analyses to identify all low-calorie sweetener products. This study did find that both groups changed macronutrient composition, and reduced intakes of total energy, carbohydrates, fat, protein, saturated fat, total sugar and added sugar (Piernas et al., 2013).

A habit based online RCT by Judah et al. (2020) investigated SSB and substitution with water of diet drinks. A total of 158 participants who were high SSB consumers were randomised across two groups, where they were asked to implement strategies to reduce their intakes of SSB with either water or diet beverages. After 2 months both groups reported a significant reduction in SSB consumption. Using a mixed model ANOVA, the authors found time significantly affected the number of SSB portions consumed, with T2 significantly lower than T1, M=3.57 and M=11.50 ($p<0.05$) respectively. There was also a reported significant effective for intervention group, however analyses of interactions between time and intervention group were non-significant (Judah et al., 2020). It is noted that the authors did not include an additional period of follow-up to assess the lasting nature of the intervention. As habitual dietary changes are required to be sustained over a longer period of time, the true effects of this study could have been missed. Considering the short time period, the authors concluded that simple intention-based intervention substantially reduced SSB consumption, with replacement by water or diet beverages equally effective.

Results from a systematic review and meta-analyses into the effects of product reformulation on sugar intake and health was reported by Hashem et al. (2019) who investigated four RCT (Gatenby et al., 1997; Markey et al., 2016; Raben et al., 2002, 2011) publications assessing the effect of sugar-reformulated products on sugar intake over a period of 8-10 weeks. In the trial by Markey et al. (2016), participants were asked to swap ≥ 1 beverage and ≥ 1 food portion each day with an equivalent sugar containing or sugar-reformulation product (Markey et al., 2016). In the trial by Gatenby et al. (1997), participants in the sugar reduction group were given instructions to substitute conventional sugar containing food with reduced-sugar foods (Gatenby et al., 1997). Hashem et al. (2019) reported after pooling estimates in a meta-analysis the following reductions: percentage sugar intake -11.18%, grammes of sugar intakes -91.00 g/day and bodyweight -1.04kg (Hashem et al., 2019). Out of the four trials included, Raben et al. (2002, 2011) saw the largest differences between groups with 492kcal/day whereas Markey et al. (2016) and Gatenby et al. (1997) observed more modest differences in energy intakes between groups of 181kcal/day and 52kcal/day. Additional research studies and national datasets were discussed in the review by Hashem, et al 2019, however were not included here due to their basis on observational research and modelling studies. In this review of ‘swap based interventions’, it was my professional opinion and judgement that only the directly related RCT’s with sufficiently described interventions be discussed here.

The effectiveness of the UK's Change4life sugar swap campaign was investigated in 49 participants including both adults and children within family groups (Lamport et al., 2022). Participants underwent a 2-week intervention where families were asked to participate in Sugar swaps using the Change4life campaign material. Immediately after there was a 2 week follow up, with a repeated 2 week follow up one year later. During the interventions phase, participants achieved reductions of over 32g of sugar, 11g of fat and 236kcal reductions, with families making on average 10 swaps. Dietary changes were predominately seen in children. In the immediate 2 week follow up 61% of the dietary benefits achieved were maintained. At the one-year follow-up there were still significant reductions in sugar, sucrose, fat, saturated fat, carbohydrates and energy while fruit and vegetable intakes increased in children however, there were no significant reductions in parents. These finding showing how long term habitual behavioural change is possible from swap-based interventions, especially when campaign materials are well targeted, as is the case with the Change4life campaign being particularly tailored to the dietary intakes of children (Lamport et al., 2022). The inclusion of this research could be critiqued as the target audience was both adults and children within a family group. It is however one of the only studies to assess the UK sugar information directly, and therefore was required for inclusion. The study itself was completed over 2 weeks with an additional 2-week follow-up. The total time period of the study was short and a longer assessment of dietary change at three or six months could have provided rich data on the utility of the Change4 life sugar swap campaign. It is arguable whether changes at 2 or 4 weeks would have been consistently maintained and therefore the real-world utility of this study is limited.

Studies investigating the use of food swaps and selections during online shopping experiments have been explored. In randomised controlled trial, 1088 UK adults who were the primary food shopper were randomised across 4 conditions, which impacted the way foods were ordered within an online shopping environment (Koutoukidis et al., 2019). Individuals who were shown foods in ascending order of saturated fat reduced intakes of saturated fat by − 5.0% (95%CI: − 6.3 to − 3.6), with those offered lower saturated fat swaps seeing respective reductions of -2.0% (95%CI: − 3.3 to − 0.6). In addition, altering the food order reduced saturated fat intakes significant more than swaps (-3%(95% CI:- -4.3% TO -2.1%) (Koutoukidis et al., 2019). Despite both interventions showing effects in comparison to control groups the authors concluded that '*Environmental-level interventions, such as altering the default order, may be a more promising way to improve food purchasing than individual-level ones, such as offering swaps'* (Koutoukidis et al., 2019)(page 13). In a similar study, Forwood et al. (2015) investigated the effects of swaps within an online supermarket with the primary outcome impacts of choices on energy density food purchases. In another large cohort of participants (N = 1610), adults were assigned to either the control, or three swap groups '*consented swaps at selection; consented swaps at checkout; imposed swaps at selection; or imposed swaps at checkout'* (Forwood et al., 2015). (page 1). After completing a 12-item shopping task, energy density of food purchased did not differ across groups (Forwood et al., 2015). The authors report, however, that energy density reduced with number of swaps accepted (effect per swap (95% CI) = -24 kJ/100 g (-35 - -14), p<0.0001) (Forwood et al., 2015), which is perhaps no surprise as the design of the study offered lower energy density options as replacements. These two online based studies provided an indication of what individuals may do within a real-world setting. They are hypothetical in nature and neither presented data of real-world food purchases, they are therefore limited by this. This research does however indicate that supermarket-based initiatives could present as an apt public health tool for changing dietary intakes and behaviours. It is accepted that there is less external validity than if the research was completed within an actual store, but it does provide valuable insight into the types of changes and interventions that may be effective.

The evidence above (Ebbeling et al., 2012; Forwood et al., 2015; Hashem et al., 2019; Judah et al., 2020; Koutoukidis et al., 2019; Lamport et al., 2022; Tate et al., 2012) shows how swap-based interventions both at home and in the environment can directly impact the dietary decisions we make. It suggests that interventions that encourage swaps to healthier foods, when accepted, are a valid tool to reduce intakes. The challenge lies in maintaining these swaps in an environment of abundant choice and temptation, while making changes achievable for individuals. The limited evidence (Ebbeling et al., 2012; Forwood et al., 2015; Hashem et al., 2019; Judah et al., 2020; Koutoukidis et al., 2019; Lamport et al., 2022; Tate et al., 2012) makes it a challenge to state whether swap-based interventions are effective in environmental public settings (e.g., supermarkets) and at home.

In swap-based reformulation interventions of SSBs, the recommendation is to replace SSBs with diet beverages are those that most likely contain low calorie non-nutritive sweeteners. It is worth nothing that studies investigating LCS substitution contain outcomes aimed at bodyweight change. Currently the use of low-calorie sweeteners and sweetened products has been suggested as a tool to help alleviate some of the adverse effects of high sugar intakes, for example bodyweight, however this remains controversial (Rogers & Appleton, 20210; World health organization, 2023). In 2023 the World Health Organization (World Health Organization, 2023) recommended that '*non-sugar sweeteners not be used as a means of achieving weight control or reducing the risk of noncommunicable diseases'* (World Health Organization, 2023)*(pg.20).* Whereas a systematic review into LCS, energy intake and bodyweight stated that '*The evidence from human intervention studies supports the use of LCS in weight management, constrained primarily by the amount of added sugar that LCS can displace in the diet'* (Rogers & Appleton,2020)(page 464.).

1.6. Extraneous variables and sugar consumption

The aetiology of our dietary intakes and eating behaviours affects numerous interconnecting and interrelated factors. Investigations into demographic, habitual, attitudinal, and genetic factors linked to dietary intakes have been observed to be associated with sugar consumption specifically. In this section, a short overview of some of these factors will be described, however this list is not exclusive and is merely described to outline extraneous variables linked to intakes.

1.6.1. Demographics

Age - Over the life-course there have been many studies investigating changes in eating habits as we age. A meta-analysis of longitudinal studies by Winpenny et al. (2017) observed that there was a decrease in added sugar consumption from the age of 13-30 years, although these findings were-nonsignificant. Further investigations in the UK taken from NDNS data of the period 2008-2014, showed that children and adolescents had the highest mean percentage of total energy intakes (TEI) from free sugars with intakes of 14%, and 15.78% respectively (Rauber et al., 2019). Comparatively, adults and those over 75 years of age in the same period had intakes of 11.93% and 11.36% respectively (Rauber et al., 2019). This downward trend in sugar intakes is not exclusive to the UK, with a recent study by Walton et al. (2023) showing that across multiple countries, sugar intake is often higher in children and adolescents than older adults with intakes of 12-14% or 8% TEI respectively. This evidence shows that age can be a significant factor in intakes of free sugar consumption. This research is only concerned with adult intakes of free sugars, between the ages of 18-64 years. Therefore, due to the large catchment of the adult age bracket, including age as an extraneous variable allows us to control for any differences across trial arms in later analyses which could potentially contribute confounding.

Socioeconomic status - The area we live, and our socioeconomic status (SES) have been shown to influence sugar consumption, particularly in studies using SSBs as indicators of intake. In a meta-analysis, it was observed that SES influenced consumption patterns of SSB's, with those in lower SES classification having higher odds of SSB consumption (Purohit et al., 2022). Bolt-Evensen et al. (2018), observed this same trend in SSB consumption from childhood to adulthood, although it was not observed for artificially sweetened beverages. These social inequities in SSB consumption have been found across the globe, with interventions needed to reduce consumption (Warren et al., 2022). It is worth nothing that although these trends in SES are likely genuine, the severity of trends in consumption may vary dependent on the SES indicator used (Warren et al., 2022, Bolt-Evensen et al., 2018). Common SES indicators include assessments of annual income, family residence, educational achievement and occupation. For example, it has been reported that higher educational attainment is connected with healthier diets, with the inverse of lower educational attainment and diets higher in consumption of carbohydrates, sweets and meat reported (Azizi Fard et al., 2021). It is not just our educational status that could contribute to dietary patterns but also our income levels (French et al., 2019; Pechey & Monsivais, 2016). In food purchase data, French et al (2019) found that households with lower incomes purchase less healthy foods in comparison to those with higher incomes (French et al., 2019). This supports earlier research which found the majority of SES differences in the choices of less healthy foods were mediated by cost (Pechey & Monsivais, 2016). The context of this study is focussed on dietary change and thusly individuals will be requested to alter their dietary habits. Socioeconomic status needs to be controlled for as if individuals are unable to undertake dietary changes due to SES factors such as financial pressure this will not be related to the dietary advice but be a confounding variable. These factors if not accounted for could have strong repercussions for bias in any analyses.

Physical activity - When looking at patterns between dietary intakes and physical activity authors reported a curvilinear relationship, with intakes of sugar or SSB reduced in moderately active individuals compared to inactive or highly active individuals (Koehler et al., 2019). Furthermore, to the aforenoted associations of age, SES, and activity levels, some studies have observed individuals of varying age, gender and ethnic groups may consume disproportionately more sugar drinks than others (Jiang et al., 2020). Evidence from cross-sectional data analyses have shown that the behaviour of physical activity is correlated to diet quality (Camões & Lopes, 2008; Gillman et al., 2001). It has been observed that individuals who have higher physical activity levels are more likely to have higher nutrient intakes of healthful foods such as fruit and vegetables, with lower intakes of saturated fat (Camões & Lopes, 2008; Gillman et al., 2001). The inverse of the trend of more sedentary behaviours and poorer dietary profiles was also seen (Camões & Lopes, 2008; Gillman et al., 2001). As these studies are observational in nature there can be some criticism for the integrity of findings. Therefore, using the gold standard of RCT investigation, research by Redman et al 2009, investigated the metabolic and behavioural adaptions to calorie restriction (Redman et al., 2009). The authors report that following calorie restriction on a low-calorie diet (890kcal), physical activity levels significantly reduced at 6 months. It was found that total daily energy expenditure adjusted for body composition, with reduced physical activity at both 3 month and 6-month timepoints (Redman et al., 2009). Although the trial by Redman et al, (2009) presents data from a high level of calorie restriction, it provided evidence showing the direct links between intakes and activity. As this research will be concerned with a message in the reduction of intakes it will be advisable to include a measure of physical activity. This is to measure whether recommendations result in increases in physical activity linked to dietary pattern improvement. Alternatively, it is important to assess if the recommendation causes and adverse reduction in calories to the point of limiting physical activity. Furthermore, physical activity could present as a confounding factor in any analysis of anthropometrics and therefore should be measured to validate findings.

1.6.2. Attitudes and behaviours

When looking at the eating behaviour, the well-known and validated Three Factor Eating Questionnaire R18 (TFEQ-R18) can help elucidate associations between consumptions patterns and behaviour. De Lauzon et al. (2004) observed that the TFEQ sub-scores cognitive restraint (CR), emotional eating (EE) and unregulated eating (UE), were associated with the consumptions of energy-dense and sugary foods. It was found that those with higher EE scores tended to have higher snacking food intakes (De Lauzon et al., 2004). Moreover, this is a trend across multiple populations in regard to sugar and sweet foods specifically (Blandine de Lauzon et al., 2004; Keskitalo et al., 2008a; Lähteenmäki & Tuorila, 1995). Including the TFEQ in a study directed at changes in free sugars may help us in understanding the influence of the intervention on behaviours such as adherence to dietary change. This measure can help identify the mechanisms behind behavioural change. Furthermore, if individuals across intervention groups have different baseline measures of the TFEQ this could adversely impact the way interventions may be received and undertaken. Therefore, to include a measure of eating behaviour in interventions of dietary change would be advised.

Attitudes and knowledge of food and therefore dietary intakes can play a crucial role in shaping eating behaviours. Although the case for knowledge and attitudes being determinant of eating behaviour and sugar intakes is much debated (A. Gupta et al., 2018a), some evidence has been found. A systematic review by Gupta et al. (2018) reported that in three cross sectional studies across two countries (n = 250, 1041 and 3926) there were associations between increased sugar knowledge and reduced sugary food and beverage consumption (Gase et al., 2014; Y. Lee & Joo, 2016; Park et al., 2013). Despite this there were also studies that reported no association between sugar knowledge and SSB intake, although this data was self-reported from college students (n = 3929, n=201) (Park et al., 2013; Zytnick et al., 2015). Associations between attitudes towards sugar and sugar intakes have been little reported in the literature. One study by Hennessy et al. (2015) found that in American female caregivers the perception of SSBs as healthy was associated with higher intakes. More needs to be done to understand these associations, although further work has provided information regarding the interpersonal factors that may contribute (Tang et al., 2021). It is important that when developing interventions for the community, they need to be both accepted and easily understood. The changes we make to one nutrient or food group, have an impact on the diet as a whole. This is especially the case with sugar intakes, with reciprocal relationships between sugar and saturated fat observed in what is often referred to as the sugar-fat seesaw. In a review by Sadley et al. (2015) a strong inverse association between percentage of total energy intake and sugars and total fats was found. The authors conclude that the percentage nature of many dietary guidelines make achievement challenging at the population level (Sadler et al., 2015).

1.6.3. Taste status

The logical association between liking for sweet foods and dietary intakes has been investigated in literature. Early research demonstrated a potential link between bitter taste perception (6-n-Propylthiouracil taste) and liking for sweet tastes (Yeomans et al., 2009). Further work assessing this sweet taste perception with liking and intakes observed a link between hedonic liking and sweet taste intensity with liking for sweet foods and intakes for energy, carbohydrates, and sugar (Jayasinghe et al., 2017). These associations have also been investigated regarding the relationship between sweet liker state, sugar intakes and bodyweight, where previous inconsistences have been reported (Iatridi et al., 2019b). In a 2019 systematic review, it was reported that measures of taste intensity were negatively associated with intakes, whereas measures of increased liking were positively associated (Tan & Tucker, 2019). The authors concluded that measures of preference of liking were likely superior to intensity measures for elucidating insights into dietary behaviours (Tan & Tucker, 2019). The mechanism behind sweet liking or disliking may in part be due to our genetics (Hwang et al., 2019). In a study using genome-wide association scans and European population data there was a reportedly strong association between single nucleotide polymorphisms (rs11642841) with phenotypes of sweet perception and intake (Hwang et al., 2019). The authors conclude '*that genes additional to those involved in the peripheral receptor system are also associated with the sweet taste perception and intake of sweet-tasting foods*' (Hwang et al., 2019)(page 1724). This study exemplifies that our perception and liking for tastes and therefore foods are in part due to our genetics (Hwang et al., 2019). In this research, individuals are to be randomised across a clinical trial for the investigation of dietary intakes of sugary or sweet foods, therefore their genetic predisposition should be assessed. Although much of the evidence discussed above is subjective in the perception of sweet liking and genetic tasting, we do know that individuals are objectively different in their ability to taste based on their genetics. This cannot be denied, and therefore, if not considered is liked to introduce either a genetic or preference bias between groups that are attempting to change. Although it is my opinion that factors like sweet liker status and super taster status, likely don't significantly impact our intakes. The current evidence is strong enough that it cannot be ignored in the context of this research and therefore, will need to be considered.

1.7. Conclusion and aims

1.7.1. Contribution to field of knowledge

Free sugars are included in many of the foods we enjoy, increasing both the energy density and appeal of foods and drinks. Increased consumption of foods and drinks high in free sugars has been linked to raised risk of multiple NCDs and significant health issues globally (2021 Global Nutrition Report: The State of Global Nutrition, 2021; Abbafati et al., 2020; Roth et al., 2020). Population estimates suggest that the majority of individuals do not achieve multiple nutrient or food-based dietary goals (Leme et al., 2021; Yau et al., 2019a). Despite national public health programmes, individuals continue to overconsume nutrients, such as free sugars (Public Health England, 2020b, 2020d) with the health and budgetary benefits from dietary change (Public Health England, 2015a) unlikely to come to fruition. It is clear more needs to be done to reduce free sugar intakes (Action on Sugar, 2022). It is evident that the type of information delivered, and the methods of delivery may impact consumer intakes directly. A strong understanding of which advice enacts greater degrees of dietary changes and will aid in stronger public health messages going forward. This study seeks to extend the limited literature on the effectiveness of nutrient-, food-, and food-substitution-based recommendations using current PHE free sugar reducing advice. It will offer a new perspective on the effects of different dietary recommendations to enact behaviour change. The research has international relevance given widespread links between diet and disease (Roth et al., 2020) and low adherence to national dietary guidelines (Leme et al., 2021; Yau et al., 2019a). This research also has the potential to contribute to a new field of research, into the types of dietary advice delivered and efficacy of public health messages.

1.7.2. Aim

The primary purpose is to assess the effects, and adherence to, three different types of dietary recommendations for reducing free sugars, on free sugar intakes over 12 weeks, in individuals consuming >5% TEI from free sugars. Secondary aims will investigate how these different recommendations affect secondary outcomes, outcomes in subsets of the trial population, and will identify potential barriers and facilitators to dietary change.

1.7.3. Objectives

1.1: To assess the effectiveness of nutrient, food and swaps-based recommendations to reduce free sugar intakes on percent of total energy intakes of free sugars from baseline to endpoint.

1.2: To assess adherence vs nonadherence rates to the dietary recommendations and drop off across the dietary assessment period and group.

2.1: To explore associations between nutrient, food and swap interventions within subgroups of the study population, including gender and BMI.

2.2: To explore associations between nutrient, food and swap interventions with attitudes and behaviours, demographic and lifestyle variables, taste outcomes and food outcomes.

2.3: To explore change in free sugar intakes and changes in dietary profiles including carbohydrates, protein, fat and saturated fat.

2.4: To explore associations between taster status, sweet attitudes and total sugar intakes.

3.0: To identify barriers and facilitators to intervention success in a subset of study participants.

1.7.4. Hypotheses

- Hypothesis (H1): Recommendation type is associated with reduction of percentage total energy intakes from free sugars at 12 weeks.
- Hypothesis (H2): Recommendation type will be associated with adherence.
- Hypothesis (H3): Reductions in percentage free sugar intake will be associated with percentage fat intakes.
- Hypothesis (H4): Sweet liker status and supertaster status will be associated with sugar intakes.

- Hypothesis (H5): Attitudes and behaviours, demographic and lifestyle variables, tastes outcomes and food outcomes will be associated with free sugar intakes, physical anthropometrics, and total energy intakes.

1.7.5. Researcher reflection one

People are driven to undertake the journey of completing a PhD for various reasons, such as professional status, academic career progression, self-growth, and love of research. Since completing earlier research in my career, I knew my reasons for undertaking the journey were very much the latter – a love of research. Searching for opportunities that aligned with my interests in nutrition within the PhD space was a challenge. At the time, and within the sector, only 5 PhD studentships were available in the country. Bournemouth University had two of these PhD studentships, however I only applied to one as I knew that was where my interest aligned. Reflecting on my application and interview, I was naïve to all the I could gain personally in this journey. I thought it would expand my knowledge and skillset, while requiring dedication and effort however, it has been so much more than that. It is throughout this process I have gained personal and professional confidence while rapidly learning skills as the research demands. It is much more than a qualification, being a reshaping of the way you see the world.

2. Methodology and Methods

This chapter will outline the research paradigm and reasoning adopted for this study. This section will provide the ontological, epistemological and theoretical rationale forming the general methodology for research design, data gathering and analysis. Due to using mixed methods in this research, inductive and deductive data analysis methods will be defined, providing high academic integrity. In the second half of this chapter the methods outlined in the running of the randomised controlled trial will be outlined.

2.1. Theoretical methods

2.1.1. Ontological, epistemological, and theoretical rationale

Ontology is defined as the study of being (Crotty, 1998). It concerns the nature of existence and structural reality within the world (Crotty, 1998). Jupp, 2006b explains ontology as '*A concept concerned with the existence of, and relationship between different aspects of society, such as social actors, cultural norms and social structures'* (Jupp, 2006b)(page 202). In essence, epistemology is the study of our knowledge regarding how we look at the world (Crotty, 1998). Epistemology relates to the nature of knowledge within a discipline, the scope of what is possible to know and what is not. SAGE defines epistemology as *'A field of philosophy concerned with the possibility, nature, sources and limits of human knowledge'* (Jupp, 2006a)*(page 92),* which requires the justification for this truth (Jupp, 2006a). The mutually dependent relationship between epistemology and ontology underpins our theoretical perspective (Crotty, 1998) and, therefore, our research methodology and methods. If our ontological approach asks, 'what is reality', epistemology asks 'what it means to know this reality' (Crotty, 1998; Jupp, 2006b, 2006a). Crotty 1998 (Crotty, 1998) outlined the four research design elements of epistemology, theoretical perspective, methodology, and methods in his research framework. These four interconnected elements (Crotty, 1998) influence the decisions we make as researchers and the overall research design of our projects.

This project is based on an ontological position of critical realism. Critical realism acknowledges that despite each individual having beliefs and personal opinions, the nature of reality does not change and is mind-independent (Bhaskar, 2008). It presumes that '*Reality is assumed to exist but to be only imperfectly apprehendable because of basically* *flawed human intellectual mechanisms and the fundamentally intractable nature of phenomena'* (Guba & Lincoln, 1994)(page 110). Critical realism must undertake a high level of examination to apprehend the closest understanding of reality (Guba & Lincoln, 1994). Therefore, although a participant may believe themselves to have lowered their sugar intake, it does not constitute the actual reality of the result, which will exist outside of their perception by being mind-independent (Archer, 1995; Bhaskar, 2008). The assumption of a critical realist ontology led to an objectivist epistemology for understanding this reality. Objectivist epistemology assumes that realities exist independent of the mind. It analyses how results objectively fit within our pre-existing knowledge, with research being reproducible to enable replicated findings (Guba & Lincoln, 1994). This epistemological position provides both reliability and external validity in the results gained. Due to the nature of research in this study, the ability to apply results to other contexts and reliably reproduce the study is vital. The outline of my philosophical perspective is essential as it reveals the underlying principles in which the researcher conducts the research methodology, methods, and data analysis. Outlined below in figure 2.1 is my research framework (Crotty, 1998).

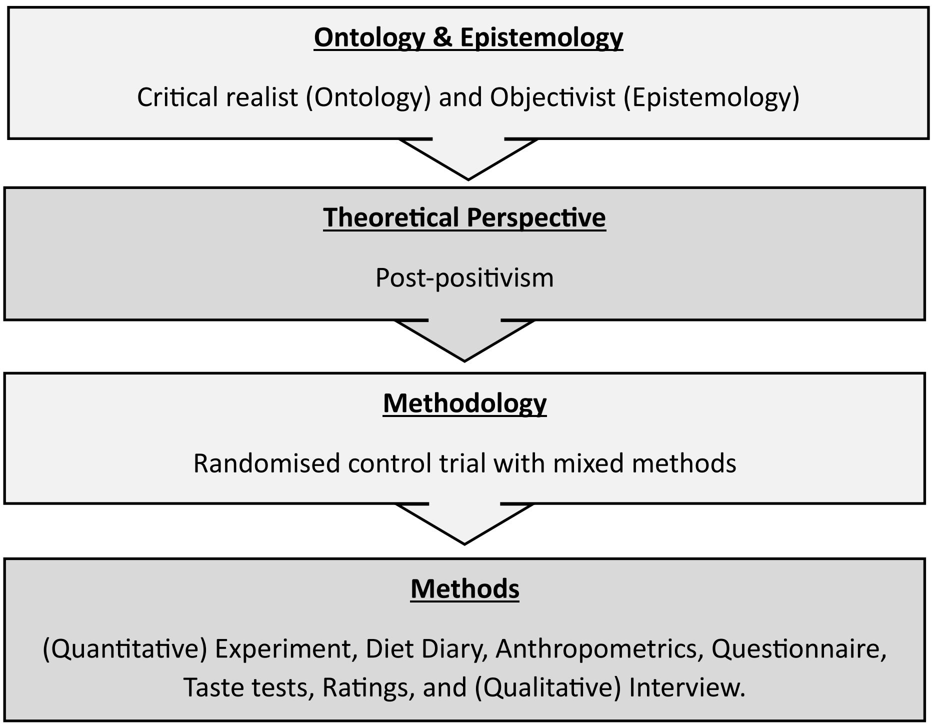

Figure 2.1: Research Framework (Adapted from Crotty (1998))

2.1.2. Theoretical perspective: post-positivism

Our theoretical perspective or paradigm is the foundation for our research. It forms our fundamental beliefs (Guba & Lincoln, 1994) and is the lens through which we see the world. Whether acknowledged or not, the assumptions we make about the reality in which our research is conducted affects the questions we ask and how we process the answers. Due to the nature of quantitative research, the paradigm underpinning this traditional scientific enquiry assumes a positivist position. Comparatively, qualitative research has four broad foundational paradigms: positivism, post-positivism, critical theory, and constructionism (Guba & Lincoln, 1994; Mittwede, 2012).

My research paradigm is one from a post-positivist standpoint. In defining post-positivism, this paradigm must be considered distinct and different from positivism. While positivists view the researcher and research as independent, post-positivists accept the inevitable subconscious researcher bias and its impact (Guba & Lincoln, 1994). Although both aim to discover objective truth, post-positivists accept the challengeable nature of human knowledge and that the discovery of 'absolute truth' is near impossible (Guba & Lincoln, 1994). Post-positivists accept that human knowledge is fallible. However, through continuing research, we can incrementally get as close to the truth as possible (Guba & Lincoln, 1994).

The nature and context of this research reinforces the justification for this post-positivist approach to this study. This study investigates the efficacy of PHE's sugar-reducing advice with the primary outcome 'percentage free sugar consumption at an endpoint of 12 weeks'. Results generated must be reproducible through strict academic rigour and the quantification of dietary data.This research has been prescribed to help provide evidence for aiding the reduction of free sugar intakes across UK adults in line with governmental recommendations whilst recognising the barriers and facilitators individuals face following said recommendations.

Using other theoretical perspectives would limit the understanding by being too strict in exploring the barriers and facilitators to change (positivism) or being too subjective to aid governmental and health regulators in their advice (critical theory and constructionism). In addition, the mixed methods research design utilised in this study benefits from this post-positivist standpoint by balancing the results generated from quantitative data into the broader exploration and reasoning themes from qualitative data.

2.1.3. Mixed method theory rationale

Mainstream psychological research during the 20th century most commonly subscribed to the 'hypothetico-deductive research' paradigm (Hugh, 2013). This paradigm is the '*method of recording observations, developing explanatory theories and testing predictions from those theories'* (Hugh, 2013)(page 26) with *'strict variable definition, measurement and control, along with structured sampling'* (Hugh, 2013)(page48). These parameters closely link the 'hypothetic-deductive' research paradigm to traditional scientific enquiry, quantification of data, and the central principles of positivism and deductive enquiry (Hugh, 2013). Qualitative researchers have criticised the hypothetico-deductive method for being too narrow and producing unrealistic results from artificial settings and enquiry (Hugh, 2013; O'Leary, 2007). Qualitative enquiry produces rich, realistic, naturalistic, but also subjective data. This subjective nature of qualitative data is also its major limitation. Without objectively reporting and determining links between different variables, we cannot make reliable recommendations for use in decision-making. Considering the context of widespread high free sugar intakes across the UK and its known links to higher calorie diets and BMI (Public Health England, 2018), this study aimed to provide supporting evidence for the delivery of free sugar recommendations to those with the highest intakes, who are most at risk from its potential ill-effects. Therefore, this research has the opportunity to provide recommendations for change to current government guidelines (NHS, 2018) and the basis for future research. It is vital that inferences made from any data gathered can be reproduced to a high level of academic validity for both quantitative and qualitative data. My theoretical postpositivist rationale justifies using mixed methods in this research within the context of historical psychology research methods (hypothetico-deductive model) (Hugh, 2013). It achieves this through positivist praise of the hypothetico-deductive research model, allowing for rigorous research in quantitative research (O'Leary, 2007) whilst not constraining broader theoretical exploration and understanding generated from qualitative enquiry (O'Leary, 2007).

2.2. Study methodology

2.2.1. Design

A protocol outlining the methodology used in this study was published in 2022 (Boxall et al., 2022) and is included in Appendix 1. Sections of this methodology are taken from the published paper with more in depth details provided. To summarise, this trial is a randomised, controlled parallel-group trial with three intervention arms and one control arm. The primary purpose is to assess the effects of three different types of dietary recommendations for reducing free sugars, on free sugar intakes over 12 weeks, in individuals consuming >5% TEI from free sugars. Secondary aims will investigate how these different recommendations affect secondary outcomes, outcomes in subsets of the trial population, and identify potential barriers and facilitators to dietary change (Boxall et al., 2022).

2.2.2. Ethical approval

Ethical approval was granted on 28.04.20 (amendments approved on 29.03.21) for this trial from the Research and Ethics Committee of Bournemouth University, UK (ref: 30612) before commencement. This study was also registered as a clinical trial on Clinicaltrials.gov (ID: NCT04816955) on 24.03.21. The trial was conducted in compliance with the Research Ethics Code of Practice of Bournemouth University, the British Psychological Society, and the Declaration of Helsinki (1983). All participants were provided with a participant information sheet and required to provide written informed consent before participating in research activities.

2.2.3. Eligibility

Individuals were eligible for study inclusion if they were healthy, aged between 18 to 65 years, residing in the South of England, consuming >5% of free sugar from TEI and met none of the exclusion criteria, including being pregnant, breastfeeding, underweight (BMI <18.5 kg/m^2), had smoked or dieted +/-3months of the start date, have any pre-existing clinical conditions or are taking any medications affecting taste/smell/absorption resulting in dietary restrictions (e.g., diabetes/Crohn's). This study opted to include individuals of all BMI categorisations >18.5 kg/m^2 for three direct reasons. Firstly, the overall design of this research was to emulate the provision of reducing free sugar recommendations designed for the healthy adult public (Public Health England, 2016c; Scientific Advisory Committee on Nutrition, 2015). Therefore, recruitment needed to consider all UK adults for whom these recommendations would be appropriately distributed to by primary care givers or national agencies. Secondly, to exclude any BMI categorisations such as obese or morbidly obese individuals, who it is acknowledged may have different dietary pattens to normative BMI adults(Newby et al., 2003; Seifu et al., 2021), would undermine the applicability of the research and potentially be discriminatory considering (Pagarkar et al., 2023; Puhl & Heuer, 2010) they would be provided the same dietary guidelines but then be misrepresented in the assessment of their utility.

Participants were excluded if pregnant, breastfeeding or underweight as the intervention provided may have asked that individual to restrict dietary intakes, making it unethical to ask this. Individuals were ineligible if they had smoked within 3 months of the study start or had medications or clinical conditions affecting taste perception, this was due to the close links between dietary taste and intakes in addition to secondary outcomes measuring changes in taste as a result of potential dietary change. Finally, individuals who had dieted within 3 months of the study start date or had existing conditions causing restricted or specialised diet plans were excluded because we are testing the primary outcome of reduction in free sugar intakes and adherence, with earlier changes or preexisting diet plans presenting as either a confounding variable to adherence or potentially opposing dietary medical advice. This study limited the inclusion age range of participants to between 18-65 years of age. This was to ensure the applicability of the UK'S free sugar recommendations (individuals 2+) (Scientific Advisory Committee on Nutrition, 2015) whilst considering the comparability to adult dietary reference values and UK national dietary datasets for free sugars and other macro/micronutrients which are divided into age categories with adults specified as 19-64 years (Public Health England, 2020c; Scientific Advisory Committee on Nutrition, 2015).

2.2.4. Sample size and randomisation

Sample size

Sample size equations were based of initial data published in Smith et al. (2015) on adherence to dietary recommendations. This study was chosen as the next best alternative due to a lack of literature reporting changes in free sugar intakes across 'dietary recommendation' interventions comparable to this study (Boxall et al., 2022).

This relationship between saturated fat and free sugars in the UK adults' diet makes it a logical substitute for free sugars for the premise of an estimated sample size equation. In Smith's study (K. L. Smith et al., 2015) saturated fat intakes provided an average of 14.4% of the TEI. This value represents a similar substitute to UK intakes of 'free sugars', with adult intakes currently 9.9% in 2019 (Public health England, 2020a). Smith et al's. (2015) reported a ~2% change in dietary intakes of saturated fat which represents a suitable lower limit of dietary change in terms of clinical significance and impact on an individual over a long-term period. Finally, although the sample size equations were not thoroughly provided in Smith et al. (2015), the sample size from their study was used when deciding the number of participants required for this study.

This study's primary aim is to test for a difference in means (pre to post) intervention in free sugar intakes. To analyse the of PHE-free sugar-reducing advice, sample size calculations for a difference in means of equal sized groups were used (Whitley & Ball, 2002).

First, as Smith et al. (2015) did not report standard deviations (SDs), the standard errors were converted to SD in both pre and post intervention levels of saturated fat. This was then averaged and the equation below used to calculate the standardized difference.

$$Standardized\ difference = \frac{Target\ Difference}{Standard\ Deviation} \qquad \frac{2}{2.4} = 0.83$$

The following specific sample size formula (Whitley & Ball, 2002) for comparing the means of four groups of equal size was as follows:

$$n = \frac{4}{d^2} \times C_{p.power}$$

'where *n* is the number of subjects required in each group, *d* is the standardised difference and $C_{p.power}$ is a constant defined by the values chosen for the *P* value and power' (Whitley & Ball, 2002). For the following calculation, a *P* value of 0.05 with 80% power was chosen, representing a value of 7.9 for $C_{p.power}$.

$$\frac{4}{(0.83^2)} \times 7.9 = 45.8$$

Therefore, 46 participants were calculated to be required in each arm of this study. Allowing for a 20% drop-out rate and unequal recruitment across trial arms, we aim to recruit 240 participants in total (Boxall et al., 2022).Health behaviour change trials report the average attrition rate at ~18% (Crutzen et al., 2015). Although this trial was not targeted at weight loss it could have been a motivator for individuals interested in dietary change, with dropouts reported at 25% for individuals tasked with following interventions that utilised national dietary guidelines (Batterham et al., 2016). High attrition rates between ~20% - 49% have been reported in dietary clinical trials (Mirmiran et al., 2021). The highest attrition rates often occurring in the case of long-term interventions >12months (Mirmiran et al., 2021). As this study include a 1-week dietary screening before enrolment, retention may be improved with the suggestion to allow for withdrawals between 10-25% (Landers & Landers, 2004). Therefore, considering the screening process, 12 week running period and subject matter, an allowance of 20% attrition was deemed appropriate.

Randomisation

Using stratified randomisation (Suresh, 2011) participants were allocated into one of four groups based on their gender, BMI and free sugar intakes at baseline. To ensure the researcher was kept blinded to the treatment allocation during data collection, a secondary researcher allocated the different intervention information into identical sealed envelopes with a unique group code on the outside of which only the 'secondary researcher' was aware. Stratified randomisation was chosen to maximise the chances of balance between each of the groups and limit possible confounding caused by the participants' gender, BMI, and free sugar intakes in the study (Suresh, 2011).

In the UK both men and women have similar intakes of saturated fat (~12%) and free sugars (~11%) as a proportion of their TEI (Public Health England, 2018). UK men generally consume greater calories (Public Health England, 2018) and those with higher BMI's have greater energy requirements to maintain their weight (Weekes, 2019) with any overall changes in total intakes of energy possibly affecting the proportion of sugar in their diet (Boxall et al., 2022). Finally, individuals with the highest intakes of free sugars as a percentage of TEI are more likely to see greater changes than those of the lower intakes, as they have greater capacity to see dietary change, although many external factors such as food availability, geography, time, cost and the environment affect dietary intakes (Caswell et al., 2013; Holmes & Roberts, 2011; K. Roberts et al., 2018; Whitelock & Ensaff, 2018).

Stratifying by these factors ensured a focus on the variables of interest to aid in minimizing confounding, allowing for effective randomisation without overcomplication of groups (Friedman et al., 2010). While including additional stratification via demographic factors such as age may have enhanced balance between groups. The inclusion criteria being restricted to ages 18-65 years combined with larger sample sizes >50 participants per group meant variability within demographics such as age was likely minimal with the necessity for additional stratification assessed to not be required (Friedman et al., 2010; Pocock, 2013; Wackerly et al., 2008). Therefore, if recruitment targets were hit, the sample size was likely large enough to balance out these different demographic characteristics across groups (Wackerly et al., 2008). In addition, the factors chosen for randomisation were governed by the primary research question helping maintain the integrity and validity of the RCT while limiting unnecessary complexity in trial implementation.

The three elements of gender, BMI and TEI of free sugars were chosen due to the more direct link between dietary intakes and profiles to ensure limited confounding effects in the validity of this study versus other more external factors (Caswell et al., 2013; Holmes & Roberts, 2011; K. Roberts et al., 2018; Whitelock & Ensaff, 2018). To adequately control the number of participants in each of the four groups and ensure each had similar proportions of gender, BMI and free sugar intakes, a coded system was used based on the previous allocation of participants into the study.

The allocated coding was as follows for; gender was female (1), male (2), or non-binary/other (3), for BMI healthy weight BMI (kg/m^2) of 18.5-24.9(National Institute for Health and Care Excellence, 2014) (1), overweight BMI (kg/m^2) of 25-29.9(National Institute for Health and Care Excellence, 2014) (2), or an obese BMI (kg/m^2) of over 30(National Institute for Health and Care Excellence, 2014) (3) , and for free sugars at baseline 5-9.9% medium TEI (1) and 10-14.9% high TEI (2). The first number denoted gender, the second BMI and the third free sugars at baseline. For example, an overweight male with 12% FS TEI, would be handed the envelope beginning with the first three numbers 222. After determining the first three numbers, the fourth and fifth represented the number of participants in that group, with the first allocated 01, the second 02, and additional participants as follows. Therefore, for a female participant, of lean bodyweight and 11% FS TEI, being the first participant of that gender, bodyweight and free sugar percentage (FS%) intakes, their code would be 112,01.

2.2.5. Intervention / Control

Participants were randomised into four study intervention arms to deliver and test three different versions of PHE free sugar-reducing advice vs. one control group (dietary record keeping). Dietary recommendations were taken from the publicly available information at the time (NHS, 2018, 2019b). The groups are outlined to include either nutrient (N), nutrient and food (NF), or nutrient, food and food swaps (NFS) elements of PHE's sugar reducing the dietary guidance, with a control group (CG) assigned recommendations to record their dietary intakes. Each group was requested to record all '*food and drink eaten' 'on the day you receive notification, using the Nutritics 'Libro' App"*. Every participant was provided with a 'how to' guide on using the Nutritics software and their intervention recommendation on the first test day. All groups were asked to '*Please keep an accurate diet diary using the Nutritics software'*. However, the dietary recommendation intervention provided differed for each group:

Group N: Nutrient-based guidelines (NHS, 2018) - Individuals receiving nutrient-based recommendations were instructed: *'Your dietary recommendation is to reduce your intake of free sugars to less than 5% of your total energy intake'.* This recommendation and the request to keep an accurate diet diary were followed by one page of nutrient-based information. This advice included how to identify the different names for sugars on ingredient lists and the sugar content of foods on the back of packaging, e.g., '*high in sugar – 22.5g or more of total sugar per 100g'*. Current recommendations at the time from PHE (NHS 2018) were amended to provide only nutrient-level information relating to sugars.

Group NF: Nutrient and food-based dietary guidelines (NHS, 2018, 2019b) **-** These recommendations began with the instruction: *'Your dietary recommendation is to reduce your intake of free sugars to less than 5% of your total energy intake. To aid with this, reduce your intake of foods high in free sugar'.* Participants were provided with the same nutrient-based information as Group N above in addition to four pages outlining which foods are likely to be high in free sugars and how much sugar they contain, e.g., '*A bowl of sugary* *breakfast cereal could contribute 70g of sugar (up to 22 sugar cubes) to your diet over a week'.* Current recommendations from PHE (NHS, 2018, 2019b) were amended to provide only nutrient- and food-based information related to sugars.

Group NFS: Nutrient, food, and food-substitution-based guidelines (NHS, 2018, 2019b; Sugar, Sweeteners and Diabetes | Diabetes UK, n.d.-b) **-** Individuals receiving these recommendations were instructed: *'Your dietary recommendation is to reduce your intake of free sugars to less than 5% of your total energy intake. To aid with this, reduce your intake of foods high in free sugar and replace these with low-sugar versions'.* The same nutrient- and food-based information that Group NF received was provided, along with five pages on low-calorie sweeteners (LCS) and low-sugar meal options. This information explained LCS, including what they are, where to find them, and their various uses. It also offered low-sugar alternatives for high-sugar items, such as "*biscuits - swap for oatcakes, oat biscuits, or unsalted rice cakes*." This data was obtained from Diabetes UK (Diabetes UK, n.d.-c) and solely contains information about LCS; all diabetes references were removed.

Group CG: Dietary logging - No nutritional advice was given to participants in the control group. These participants were only given the same guidance on maintaining a precise diet diary. Individuals were verbally informed at the test day they would receive dietary recommendations ranging from increasing or decreasing a food group, or just logging their diet diaries. Participants were instructed that the 'recording and logging of all food and drink items consumed' was still a dietary recommendation. Therefore, if participants received the recommendation to just log their dietary intakes it was to be treated as a dietary recommendation.

2.2.6. Intervention Delivery

Participants were provided with their interventions in sealed envelopes following baseline measures. Individuals completing measures from home had their recommendations posted after their test day Zoom. All intervention/control instruction booklets were delivered to participants in a sealed envelope alongside a user guide for Nutritics Libro App (Nutritics, 2019), shown in appendices 2 and 3 respectively. The instructions for the diet diaries were identical for all groups. However, they had been carefully worded so that participants in the control group would take them as dietary guidelines. Upon receiving their sealed envelope, all participants were notified that we define a dietary recommendation as anything from keeping track of your diet via logging, to increasing or decreasing your intake of certain foods. For example, participants were verbally instructed with the following at the test day "*Inside this envelope is your dietary recommendation we would like you to follow for the next 12 weeks. I don't know which recommendation you have been specifically allocated and it's important that you don't tell me. The types of dietary recommendation you may receive include increasing intakes of fruit and vegetables, pulses, or decreasing your intakes of things like sugar, salt, fat, or simply just logging your diet. We still classify dietary logging alone as a dietary recommendation, so even if no foods are specified you have still been provided with a recommendation."* Participants were asked not to reveal their study allocation to the main researcher (LRB), with any questions regarding clarification of the dietary recommendations provided by the primary supervisor (KMA) to participants directly. This was designed to better replicate current public health recommendations, which are delivered via government messages, TV adverts, and leaflets. This also ensures that the main researcher (LRB) remained blinded to the allocation of the dietary interventions. Appendix 3 provides complete copies of each intervention as it was given to participants.

Blinding

The researcher doing the randomization (KMA) ensured that each envelope with the intervention and control booklets was identical, sealed, and coded. To ensure researcher blindness, all envelopes were prepared to include the same number of pages, regardless of group, by including additional blank pages as needed. Throughout data collection, the researcher in direct contact with participants (LRB) remained blinded to treatment assignment. Participants were blinded to the trial's true goal and to all interventions but their own. All participants filled out additional questions to those focusing on sugar, to further obscure the trial's intended goal.

2.3. Quantitative testing methodology

Our primary outcomes are percentage free sugar intakes (at week 12) and adherence to the dietary recommendations over a 12-week period. Secondary outcomes are: daily energy intake, dietary composition anthropometry, sweet food choice, attitudes to sweet foods, attitudes towards eating behaviour, motives for food choice, knowledge and lifestyle variables, quality of life and adverse events. Secondary qualitative outcomes are: barriers and facilitators towards intervention adherence and success / failure in achieving the recommendations. Sweet liker status, 6-n-Propylthiouracil (PROP) status, and demographic variables will also be assessed to aid in the interpretation of all outcomes (Boxall et al., 2022). Additional data on taste perceptions and preferences was collected for my primary supervisor (K.M.A). However, data on taste perceptions and preferences are not part of this thesis. Methodology is provided in Appendix 4.

2.3.1. Dietary outcomes

Dietary data

In previous dietary research, paper-based methods have been the most common way to record dietary intakes (Hooson et al., 2020). The validity of newer electronic methods such as mobile dietary apps for recording diet diaries have been shown to produce no significant differences in mean nutrient estimates compared to dietitian-entered 3-day dietary records (Raatz et al., 2015). Considering the underlying purpose of this research was to emulate the provision of dietary recommendations within an environment as close to a real-world context. The gathering of dietary data needed to benefit from the lower subconscious bias and reduced researcher contact. Therefore, electronic methods for recording of diet diaries were chosen both to compliment the purpose of this research but also to reduce any bias caused by regular direct contact with the primary researcher. In addition, accounting for the design and size of this study the historical paper-based method would have led to an inefficient loss of work hours. Therefore, electronic dietary assessments also benefitted this study by reducing the cost of researcher burden (Hooson et al., 2020).

Nutritics and Libro App

The Nutritics software (Nutritics, 2019b) platform (Research Edition, v5) was chosen for this study due to its extensive nutritional food database (>750,000 foods) and its widespread use in current literature (Carboni et al., 2019; Evans et al., 2019; Hanbazaza & Mumena, 2020; Michael et al., 2019; Morris et al., 2020; S. L. Robinson et al., 2015; Routledge et al., 2020; Sabbagh et al., 2020). Nutritics (Nutritics, 2019b) has not only been widely used for the collection and recording of dietary information (Michael et al., 2019; Morris et al., 2020; S. L.

Robinson et al., 2015) but also for the analysis of nutrient components in the diet (Carboni et al., 2019; Routledge et al., 2020). Nutritics is the first food data management software to achieve a gold standard for recipe calculating methodology that meets European regulations for providing food information to consumers (Regulation 1169/2011), as awarded by the European Food Information Resource AISBL (EuorFIR) (Nutritics, 2024). All food data is validated across multiple levels within Nutritics to ensure confidence in the validation of their food composition data. Participants benefitted from the latest Nutritics (Nutritics, 2019b) technology and food database through the mobile 'Libro' App' (Nutritics, 2019). Libro (Nutritics, 2019) which has been successfully used and reported in current literature (Evans et al., 2019; Hanbazaza & Mumena, 2020; Sabbagh et al., 2020; Scanlon & Norton, 2024). Libro provides a viable and logical choice for participants to self-report their food intake without the researcher's influence across the intervention period.

Data gathered through Nutritics (Nutritics, 2019b) was stored on their cloud servers until downloaded onto the student H drive in accordance with data management principles. Nutritics (Nutritics, 2019b) benefits from encrypting all communication between the computer used and their servers to a bank-level security of 256-bit SSL, ensuring the security of participants' data while the study was running. All dietary screening was completed using the Nutritics software, with potential participants trained using written instructions on using the Libro 'App' provided by the postgraduate researcher (PGR). Baseline and endpoint usual intakes were calculated from three non-consecutive diet diaries (one weekend day and two weekdays) collected using Nutritics.

Figure 2.2: Libro app interface (Nutritics, 2019)

Schedule of dietary measures

In order to capture usual dietary intakes and observe adherence to recommendations, frequent dietary measurements were required. Observations on the differences between weekdays and weekends on dietary intakes have been reported (An, 2016; Whitton et al., 2011) therefore, the dietary measurement schedule needed to reflect these differences. To adequately measure 'usual' baseline dietary intakes of free sugars, the mean nutrient intakes across the three diet diaries were calculated. This methodology helped limit the possibility of measurement error caused by intra-individual variations in distributions of intake seen in single or two-day mean intakes.

The first ten diet diaries were recorded every three days, then every six days for diet diaries 11-19, and every two days again for diet diaries 20-21. This schedule was decided on to capture adherence to recommendations while allowing for the comparison of the usual intakes gathered in week 12 (example shown in table 2.1).

Table 2.1

Scheduled diet diary recording to measure compliance.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Base	DD	*	DD	*	*	DD	*
Week 1	DD			DD			DD
Week 2			DD			DD	
Week 3		DD			DD		
Week 4	DD(+)			DD			DD
Week 5				DD			
Week 6			DD				
Week 7		DD					
Week 8	DD						DD(+)
Week 9						DD	
Week 10					DD		
Week 11				DD			
Week 12	DD		DD			DD(+)	

DD = Diet diary, including perceived adherence questions * baseline refers to record of any 3 days of diet (to include 1 weekend and 2 weekdays) (+) refers to additional questionnaires delivered during the study. The DFS and TFEQ questionnaires were delivered at weeks 4, 8, and 12 during the study (+).

Adherence and compliance

Diet diaries were also used to assess adherence to the dietary recommendations. Adherence was assessed from every diary and then classified five times across the 12-week intervention. During the first two weeks of the trial, adherence was based on participants' ability to reduce free sugars by ≥2%TEI from baseline or achieve <5% TEI, or not, classified as 'adherent' or 'non-adherent', respectively. Participants were then classified at weeks 4, 8, and 12 using data on their ability to reduce free sugars by ≥2%TEI or achieving <5% TEI, from their previous baseline assessment (baseline for week 4) and their answers to the following adherence question: '*Are you currently following the dietary recommendations you were given?'* Reductions of free sugar intakes ≥2%TEI or achieving <5% TEI and an answer 'YES' will result in a classification of 'active adherent', reductions of free sugar intakes ≥2%TEI or achieving <5% TEI and an answer 'NO' will result in a classification of 'passive adherent', reductions of free sugar intakes <2%TEI and an answer 'NO' will result in a classification of 'active non-adherent', and reductions of free sugar intakes <2%TEI and an answer 'YES' will result in a classification of 'passive non-adherent' (Boxall et al., 2022).

Compliance with study measures was enhanced by utilising bogus pipeline methodology (Adams et al., 2008; Hugh, 2013; Muhlheim et al., 1998; Reid et al., 2014; Strang & Peterson, 2020) through a cheek swab. Participants were asked to provide a saliva sample at the start and end of the study via a non-invasive cheek swab. Participants were informed that '*Cheek/saliva swabs will be collected at the start and end of the trial and may be used to examine any differences in saliva and enzymes present in the mouth which may have been caused by dietary change. These swabs may also be analysed for genetic information and related to taste preferences later if consented.'(Shown in Appendix 10)* . Although there is no such test to examine the change in oral enzymes in this study, the information provided to participants uses the bogus pipeline method to enhance compliance and minimise the potential underreporting issues associated with dietary recalls (Adams et al., 2008; Hugh, 2013; Muhlheim et al., 1998; Reid et al., 2014; Strang & Peterson, 2020). This method has been successfully used in other studies when requesting self-reported data from participants (Adams et al., 2008; Hugh, 2013; Muhlheim et al., 1998; Reid et al., 2014; Strang & Peterson, 2020). These saliva samples were collected on both test days and immediately discarded. Only at the end of the study was the participant informed that *'their saliva/cheek samples have not been analysed, with their samples now destroyed'.*

Sweetener and sweet food counts

All unique foods logged by participants were coded into different categories, including foods that contained sweeteners, were high (*more than 22.5g of sugar per 100g*) (NHS, 2023), medium(*more than 5g but less than or equal to 22.5g of sugar per 100g*) (NHS, 2023), low (*less than or equal to 5g of sugar per 100g*) (NHS, 2023) or 'no' in sugar (0g per 100g). Counts of each food item consumed were calculated for baseline, timepoints 1-4, and endpoint. These scores were also transformed into percentage intakes of each food type.

2.3.2. Anthropometric outcomes

Current literature surrounding BMI and waist circumference measurements and their links to health risks, sugar, and energy intakes provided relevance for including these measures in this research (Morenga et al., 2013; Wei et al., 2006). A 2013 meta-analysis of dietary sugars and body weight reported that reducing the intake of dietary sugars significantly decreased body weight (-0.80kg), with the inverse also found for increased intakes (+0.75kg) (Morenga et al., 2013). These changes in body weight were related to altered overall energy intakes rather than isoenergetic substitutions with other nutrient groups (Morenga et al., 2013). They concluded that advice related to the moderation of sugar intakes is relevant to strategies aimed at reducing the risk of higher BMI prevalence (Morenga et al., 2013). When considering anthropometric measurements and high BMIs, it is not only overall weight but the location of this adiposity concerning health risk that is important. It was found that waist circumference measurements had the strongest associations with health risk factors regarding the metabolic syndrome (Wei et al., 2006).

In order to meet secondary outcomes regarding changes in BMI and to allow a discussion around the proportion of fat reduced from the waist circumference as a marker for health risk and adiposity, it was necessary to reliably record the weight, height, and waist circumferences on the first (baseline) and second (endpoint) test days. Bodyfat measures were also gained for participants attending Bournemouth University (BU). The PGR researcher carried out all anthropometric measurements. The PGR had been previously trained to reliably measure individuals, weight (kg), height (cm), and waist circumference (cm) during their undergraduate nutrition degree. An instructional booklet on the methods used to gather this information during the trial reliably is included in the handbook (shown in Appendix 5). To ensure comparability between start and endpoint measurements, the same set of digital scales (Tanita Body Composition Analyzer BF-350), stadiometer >2m, and flexible measuring tape were used for all participants. All tools used to measure anthropometrics were cleaned and disinfected between participants following proper infection control practices.

For participants attending Bournemouth University, bodyweight and bodyfat measures were taken using the same set of digital scales (Tanita Body Composition Analyzer BF-350). Bodyfat measures on the Tanita scales are completed via bioelectrical impedance analysis (BIA) which is a non-invasive validated measure of body composition via the passage of a small electric current as it passes through bodily tissues (Vasold et al., 2019). Individuals were asked to remove all heavy outdoor items of clothing such as hats, gloves, shoes and socks. Additional participants were asked to empty their pockets and remove items such as watches. The scales were then calibrated to the individuals' gender and height before participants were asked to step onto the scales, standing still until the scales had accurately read their weight and body fat. Participants then stepped off the scales and the readings were recorded by the researcher (PGR). As bare feet were required for the bodyfat measurement the research disinfected the scales pre and post use.

2.3.3. Questionnaire delivery

Each questionnaire was delivered electronically to participants in a predetermined order and completed before test day measures. After gaining consent for study parameters, individuals completed the participant demographic form, Godin-Shephard Leisure Time Physical Activity Questionnaire (GSLTPAQ) (Amireault & Godin, 2015) Food Choice Questionnaire (FCQ) (Steptoe et al., 1995), sweet food questionnaire (SQ) (C. Tang et al., 2024), 36-Item Short Form Survey (SF-36) (Ware et al., 1993), TFEQ-R18 (Cappelleri et al., 2009; Karlsson et al., 2000) and a distractor questionnaire on pulses intakes and attitudes. The full transcript of questionnaires is included in Appendix 6, as delivered in that order to participants at baseline using Qualtrics.

Due to the absence of a large-scale reported pilot study, questionnaires selected for this study were required to have been previously validated or reliably tested for inclusion. Test and re-test Cronbach's alpha (α) and Kappa coefficients (κ) were required to either meet or exceed ($\alpha > 0.7$) and ($\kappa = 0.60$-0.79) levels of agreement (McHugh, 2012). All questionnaires; GSLTPAQ ($\kappa = 0.65$) (Amireault & Godin, 2015) FCQ (all scores $\alpha > 0.7$) (Steptoe et al., 1995), TFEQ-R18 ($\alpha > 0.70$ but <0.90) (Cappelleri et al., 2009; Karlsson et al., 2000), SF-36 ($\alpha > 0.80$)

(Jenkinson et al., 1999)) reported statistical values meeting parameters. For the sweet questionnaire the following Cronbach alphas were reported, PC1 (α = 0.81), PC2 (α = 0.76), PC3 (α = 0.69), PC4(α = 0.68), PC5 (α = 0.78) and PC6 (α = 0.66) (C. Tang et al., 2024). Although factors PC3, PC4 and PC6 reported levels $\alpha > 0.7$, the questionnaire was included due to the relevance of sweet attitudes to this project.

2.3.4. Attitudes and behaviour

The three-factor eating questionnaire (TFEQ-R18) is a shorted version of the original TFEQ designed to measure three factors of eating behaviour: cognitive restraint (CR), uncontrolled eating (UE), and emotional eating (EE) (Cappelleri et al., 2009; Karlsson et al., 2000). Participants were asked to self-report different aspects of their eating behaviour by answering 18 questions marked on a 4-point scale. Scores were then calculated for the three scales (CR, UE, and EE). The CR, UE, and EE factors have previously been associated with consumption and liking of sugar and sweet foods in French, British, and Finnish populations, respectively (Blandine de Lauzon et al., 2004; Keskitalo et al., 2008a; Lähteenmäki & Tuorila, 1995). Understanding CR, UE, and EE appetitive traits in a population of high free sugar consumers can help future studies be more predictive in the tailoring of their nutritional advice. These valuable insights into this unique group of the population may help develop strategies for treating dietary weight management in those consuming excess free sugars (Cappelleri et al., 2009).

The Food Choice Questionnaire (FCQ) (Steptoe et al., 1995) is a multi-level measure of the motives related to food choice. Participants were asked 36 questions regarding food choice, with answers scored on a 4-point scale (Steptoe et al., 1995). Scores were then related to the nine factors of food choice: health, mood, convenience, sensory appeal, natural content, price, weight control, familiarity, and ethical concern (Steptoe et al., 1995). This FCQ has been frequently used in literture to describe the motivations behind food choice (Cunha et al., 2018). By understanding questions such as ;were individuals with higher weight control scores more likely to change their dietary intakes during the intervention? And other food choice motaivation questions we can better modify dietary advice for high-free sugar consumers. A recent study utilisted this questionnaire to help understand the motivation behind food choices in irish teens (Daly et al., 2023). The authors explained how by better understanding the factors that influence food choices we may enhance our ability to identify reasons why dietary recommendations are not followed and create more effective health promotion messaging (Daly et al., 2023).

The Sweet questionnaire (SQ) used in this research was developed by a Bournemouth University PGR as part of collaborative investigations into attitudes and intakes of sweet foods, sugar, and LCS. The questionnaire explores the '*relationship between attitudes towards and intake of sweet foods, sugars, and sweeteners'* (Tang et al., 2021) by providing a measure to estimate intakes of sweet tasting foods, sugar, and sweeteners in addition to participants '*attitudes related to these food items'* (Tang et al., 2021). Attitudes towards foods were assessed through a 5-point Likert Scale. Consumption of foods can be estimated but was not done here due to the use of diet diaries at the same time points. Questions contributed to six subscale scores, personal impact (PC1), personal management (PC2), apathy (PC3), negativity (PC4), perceived understanding (PC5) and perceived non-autonomy (PC6).

2.3.5. Demographics, lifestyle, and knowledge outcomes

Demographics - A short demographic form was created for this study to control for any large-scale differences between groups as possible confounders. In addition, this information was needed to evaluate the diversity of the sample population and thus the applicability of this research to different groups. The demographic form included questions on each participant's: gender (Haseldon & Joloza, 2009), age, nationality, ethnicity, occupation, education, religion, diet type, income level, and whether they were the main cook in the household. These demographic aspects have been shown to influence dietary behaviour (Smeaton et al., 2011). Questions regarding occupation were adapted from the National Statistics Socio-economic Classification (NS-SEC). The official ONS eight-category version of the NS-SEC was used in this study (Office for National Statistics, n.d.; Rose & Pevalin, 2001). Example occupations were provided alongside the NS-SEC categories and were utilised from a previously published journal article (Drever & Doran, 2004). Groups and categories related to ethnicity were based on current UK government classifications (GOV.UK, 2021) as guided by the ONS (Office for National Statistics, 2021). Participant intake was not classified by religion; however, to minimise any large-scale reporting issues, the question '*Will your religion affect your diet intake over the next 12 weeks (e.g., holidays or fasting)*' was proposed to all participants to control for these potential dietary anomalies.

The income question asked participants whether they had ‘sufficient,’ ‘insufficient’, or ‘very insufficient’ income (Dubois et al., 2011). The complete demographic form used for participants is shown in Appendix 6.

Physical Activity was assessed using the Godin-Shephard Leisure-time Physical Activity Questionnaire (GSLTPAQ) (Godin, 2011; Godin & Shephard, 1985). This assessed the exercise patterns of each intervention group at baseline and endpoint. This accounted for potential baseline confounders in activity levels and secondary outcomes regarding body weight changes. When combined with a dietary intervention, increases in exercise patterns are more likely to induce body compositional changes than with diet or exercise alone (Clark, 2015; Foster-Schubert et al., 2012). Therefore, a questionnaire accounting for participants' level of leisure time activity was required to make commentary regarding bodyweight changes in each group and meet secondary aims. The GSLTPAQ has been validated for use in healthy adults (Amireault & Godin, 2015; Godin, 2011; Godin & Shephard, 1985) and recently cited in eating behaviour (Annesi & Johnson, 2020; Barrington & Beresford, 2019; Kerrigan et al., 2019), diet and nutrition literature (Benau et al., 2019; Boushey et al., 2017; Heredia et al., 2020; Panizza et al., 2020). It allows calculated leisure time activity levels to be discussed concerning the health benefits associated with exercise (Amireault & Godin, 2015; Godin, 2011; Godin & Shephard, 1985). The GSLTPAQ’s format reduced the potential burden on participants compared to other well-known exercise questionnaires, such as the Global Physical Activity Questionnaire (GPAQ)(Cleland et al., 2014) and the International Physical Activity Questionnaire Short form (IPAQ-SF) (P. H. Lee et al., 2011). The GSLTPAQ is a self-reported four-item questionnaire regarding the number of times the participant engaged in mild (minimal effort), moderate (not exhausting), and strenuous (heart beats rapidly) exercise over seven days (Godin, 2011). The leisure time physical activity scores (LTPA) calculated from the GSLTPAQ enabled the participant sample to be categorised as ‘active’ or ‘insufficiently active’. The classification of the categories in the original study was based on the American College of Sports and Medicine (ACMS) physical activity guidelines (U.S. Department of Health and Human Services, 2008, 2018). The ACSM states that all healthy adults (18-65 years) need to complete moderate-intensity exercise for 150 minutes or vigorous-intensity exercise of 75 minutes per week to meet guidelines (U.S. Department of Health and Human Services, 2008, 2018). The most recent

2019 UK adult (19-64 years) recommendations (Department of Health & Social Care, 2019) are consistent with the ACSM guidelines of physical activity (U.S. Department of Health and Human Services, 2008, 2018) further validating the use of the GSLTPAQ (Amireault & Godin, 2015) in an English study sample for its relevance to government guidance. Due to the nature of this questionnaire, slight changes in exercise are less likely to be evidenced however, was deemed appropriate for use in this research as the information delivered was not targeted at weight loss or physical activity changes but at free sugar intakes (Boxall et al., 2022). This questionnaire has been validated for use as outlined above (Amireault & Godin, 2015; Godin, 2011; Godin & Shephard, 1985), it provides support for anthropometric changes that could arise solely form large changes in physical activity across a large sample size. This research study included this measure for indicating if large scale activity changes occurred and for commentary regarding lifestyle practices.

The Short Form Survey (SF-36) (Ware et al., 1993) questionnaire was developed as part of the Medical Outcomes Study designed to evaluate individual quality of life. The SF-36 is perhaps the most widely used and evaluated health status tool in RCTs (Contopoulos-Ioannidis et al., 2009; Garratt et al., 2002). Including individual quality-of-life measures is vital in order to endorse an intervention. The version used in this study is called the 'RAND SF-36' or MOS SF-36 (Rand Corporation, n.d.). The SF-36 includes 36 questions contributing to eight subscale scores: physical functioning (PF); role limitations due to physical health (RLP); role limitations due to emotional problems (RLE); energy/fatigue (EF); social functioning (SF); bodily pain (BP) and general health (GH). Following the currently reported methodology (Matcham et al., 2016; Rand Corporation, n.d.) and SF-36 manual (Ware et al., 1993), subscale scores alongside population scores from a normative UK dataset (Jenkinson et al., 1993) were used to calculate two summary scores: the mental component summary (MCS) and physical components summary (PCS).

Knowledge - Qualitative knowledge answers were converted to quantitative counts. For each healthy eating recommendation identified, e.g., 'five a day', 'reduce fat', or 'increase fibre', participants were given a value of 1. If participants quoted the 'Eatwell Guide' or 'NHS guidelines' a value of 1 was given; however, if additional recommendations were identified, this was discounted to avoid duplication. For example, if an individual wrote 'Five a day', 'reduce fat', and 'Eatwell Guide', they would be given a value of 2. Knowledge of a sugar recommendation required participants to identify sugar as needing to be reduced, e.g., ‘reduce sugar’. If a participant identified a sugar recommendation, they were given a value of 1; those that did not were coded as 0. No additional scores were given for the identification of ‘reduce sugar beverages’ or ‘eat less chocolate’, as the sugar knowledge score is utilised as a quantitative measure of awareness of a sugar recommendation alone and not summative of the breadth and application of that knowledge.

Adverse events were self-reported. Participants were asked to report adverse events at any time, regardless of whether they considered these to be associated with the trial. Specific questions on difficulties undertaking the study were asked at weeks 4, 8, and 12, and specific investigations of adverse events were verified at the study's end.

2.3.6. Taste outcomes

Two separate taste measures were included in this study. Sweet liker status was assessed by both a liquid and paper strip. Supertaster status was assessed by a PROP strip, followed by a weighted breakfast. The full methodology provided to participants is included in appendices 7 and 8. Participants were given a glass of low-density mineral water (Volvic Danone still) and instructed to rinse their mouth before tasting each liquid, or paper. After rinsing, they were asked to spit the water into another cup before waiting 30 seconds to begin that taste test. They would then immediately answer/ rate the question on taste. This method was repeated between each item tasted.

Appetite ratings for hunger (‘how hungry are you’), fullness (‘how full do you feel’), prospective consumption (‘how much do you think you can eat’), and desire to eat (‘how strong if your desire to eat’), (Flint et al., 2000) were taken using 100mm visual analogue scales (VAS). This was completed three times on each test day by participants: at the start of the day (preceding anthropometric measures); after the tasting of PROP and control taste strips; the breakfast meal was provided. Participants at home only completed two measures of appetite ratings due to the absence of breakfast.

Sweet liker status was assessed in all participants due to associations between sweet and bitter taste perceptions, liking, and food intakes (Jayasinghe et al., 2017; Yeomans et al., 2009). Sweet liker status is classified using 1M aqueous sucrose solutions and reported methodology (Iatridi et al., 2019b, 2019a). Participants reported perceptions of sweet taste intensity using a 100mm pen and paper version of the general labelled magnitude scale (gLMS) with intensity descriptors of' no sensation, barely detectable, weak, strong, very strong and strongest imaginable sensation (Bartoshuk et al., 2002), following training in the use of the gLMS (Bartoshuk et al., 2002; Yang et al., 2019). Sweet liking was assessed using 100mm VAS scales, with liking ratings subsequently used to categorise participants as either 'sweet likers', 'inverted U shaped', or 'sweet disliker' phenotypes. To allow for any situation where the solutions may not be available or appropriate, tests will also be conducted using a sweet taste paper saturated in the same 1M solution (Boxall et al., 2022). Assessing the proportion of the study population who are 'sweet likers' will enable understanding of whether this phenotype influences the success or failure of dietary interventions to reduce free sugar intakes. In addition, this will help clarify some of the reported inconsistencies regarding the relationship between sweet liking phenotypes; free sugar intakes and body weight by using the most recent classifications (Iatridi et al., 2019b).

PROP taste sensitivity is assessed using a taste paper impregnated with 6-n-propylthiouracil (PROP) (Precision Laboratories, Inc). Participants were asked to mark the intensity of the bitter taste using 100mm gLMS, a 100mm VAS scale, and a 9-point category scale to allow comparability with other studies (Drewnowski et al., 2001). Participants are classified as 'non-tasters', 'medium-tasters' or 'super tasters' according to published classifications for the gLMS (Bartoshuk et al., 2002, 2005; Lim et al., 2008). Earlier work by Yeomans has shown that PROP taster status is associated with liking for sweet tastes, with PROP supertasters mostly presenting as sweet disliker's (Yeomans et al., 2009). In order to undertake the PROP taster test, participants were first trained in using the gLMS (Green et al., 1993, 1996; Yang et al., 2019). The PGR researcher provided written instructions on how to use the gLMS and verbally explained the process (handbook/booklet Appendix 8). The gLMS asks individuals to mark perceived intensity between 'no sensation, barely detectable, weak, moderate, strong, very strong, and the strongest imaginable sensation' (Green et al., 1993, 1996; Yang et al., 2019). Participants were first instructed to practise using the scale by rating the intensity of five remembered sensations relevant to the strength of their chosen strongest sensation (Green et al., 1993, 1996; Yang et al., 2019). Secondly, water was used to cleanse the palate before placing the first taste strip on the tongue for 5 seconds. Participants were then asked to mark the intensity of the bitter taste using the gLMS. Participants were classified as either non-tasters, medium-tasters, or supertasters according to published classifications for the gLMS (Bartoshuk et al., 2005; Green et al., 1993). Additional ratings for bitter taste using VAS and numerical scales (Drewnowski et al., 2001) were collected to enhance comparability of data but not utilised in this thesis or analyses. After the first taste paper, the cleansing of the palate was repeated before tasting the second taste paper and again rating the perceived intensity of the bitter taste. On completing this test, participants repeated the appetite ratings mentioned above.

Figure 2.3: Sweet liker tests

2.4. Qualitative testing methodology

2.4.1. Interview design and participants

A single time-point interview during the dietary intervention stage was used in this research. The interview aimed to gain a greater level of understanding to the barriers and facilitators contributing towards successful dietary changes. The interview used questions developed specifically for this study by the postgraduate researcher with advice from supervisory team members (K.M.A & E.A.C). The interview asked participants about the barriers and facilitators they faced when following their specific dietary recommendations. However, the researcher did not ask detailed questions regarding the dietary recommendations to ensure that blinding to group allocation remained intact. Interview participants were a sub-group of participants from the main dietary recommendation study who had consented to be contacted for an optional interview. Once consent was given, individuals were randomly selected for interview at a random time point.

To ensure equal sample sizes of each intervention arm and intervention timepoint were represented in the qualitative interview, a process of covariate adaptive randomisation was used when selecting interview participants (Suresh, 2011). Once participants had been randomised into the main study and provided consent for an interview, they were immediately assigned a provisional timepoint interview. The script and interview were written and undertaken in a semi-structured style. This method was chosen due to the collection of both quantitative and qualitative data in this study and the style of analysis (framework analysis) chosen as governed by the secondary research aims (barriers and facilitators to change) (Braun & Clarke, 2013). All interviews were undertaken via telephone or zoom. Two methods of audio recording were used to minimise loss of data: a Dictaphone; and software on a mobile phone (tape'a'call) to record the whole phone call. All data was handled according to ethics guidelines, ensuring that once the call had taken place and the data been transcribed, the original audio recording was destroyed. Only the anonymised transcription remained on BU's secure server.

At the start of the interview the participant was asked if they were 'available for the interview,' having prearranged the interview date ahead of time. If they answered 'no' the interview was rescheduled. If they answered 'yes', a brief outline of the interview was explained, and verbal consent for the interview and interview recording obtained. Participants were asked to state their name on the recording before the interview could start. The interview was scripted; however, it was delivered in a semi-structured interview style. Questions were developed to cover the six types of questions postulated by Patton (Patton, 2014). They included questions about opinions/beliefs, feelings, knowledge, behaviour/experience, sensory, and background or demographic characteristics. As Patton (2014) recommended most questions were open-ended to encourage descriptive expression from participants, questions on opinions, beliefs and feelings were presented earlier in the questionnaire than the background/demographic questions to prevent participants from becoming disinterested (Brayda & Boyce, 2014). Questions were focussed towards the experience of participants in following their dietary recommendation. The order and wording of the script is included in Appendix 9.3

2.4.2. Barriers and facilitators testing

Framework analysis (FA) is a comparative form of thematic analysis (J. Smith & Firth, 2011) and was chosen as a suitable analytical method for evaluating the qualitative interview data gathered. Using framework analysis, qualitative data could be further quantitatively analysed while allowing for comparison where appropriate. Framework analysis was also chosen due to the aim of the research question concerning the barriers and facilitators reported to changing free sugar intakes when following the different dietary recommendations. This question regards individuals' experiences and seeks to identify the factors (barriers or facilitators) contributing to successful or unsuccessful dietary change. Therefore, the type of data gathered (interview), research aims, and theoretical post-positivist perspective led this research to use FA when evaluating qualitative semi-structured interview data (Braun & Clarke, 2013). The practical methods for conducting FA follow a 7-phase methodology as outlined by Gale et al. (2013).

To verify codes used and themes identified the following work was completed; the qualitative codebook was agreed between two researchers once data saturation was reached (L.R.B and K.M.A); 10% of transcripts were double coded by K.M.A; themes and subthemes were reviewed by two senior academics (K.M.A and E.A.C) with one being a specialist in qualitative research (E.A.C). Qualitative analyses were undertaken and written up solely by the PGR (L.R.B) and will require verification ahead of peer review publication. Further detail of work undertaken at each stage of the analysis is available in section xx.

2.4.3. Framework analysis

Framework analysis is a distinct form of qualitative investigation in that all participants are represented across a framework matrices. Researchers are then able to answer specific research questions via filtering through multiple layers of population data without losing the original data. Framework analysis was developed in the 1980's by Ritchie and Spencer for the purpose of applied qualitative research objectives (Ritchie & Spencer, 2002). Applied research can be described as investigations with the aim of meeting specific needs or actionable outcomes. Ritchie and Spencer describe four key areas of applied qualitative research for which Framework analysis is suitable (Ritchie & Spencer, 2002).

1. *'Contextual: identifying the form and nature of what exists.'*
    a. For example, individual experiences and population needs.
2. *'Diagnostic: examining the reasons for, or causes of, what exists.'*
    a. For example, what causes an individual's perception or attitude.
3. *'Evaluative: appraising the effectiveness of what exists.'*
    a. Are there barriers or facilitators to policy or systems.
4. *'Strategic: identifying new theories, policies, plans or actions.'*
    a. What can be done to make policies more effective.

Quotes taken from (Ritchie & Spencer 2002)(page 307)

Since its conception 'Framework analysis' (FA), also called the 'Framework approach' or 'Framework method', has be used across healthcare research (Gale et al., 2013; J. Smith & Firth, 2011). Investigations using FA include parental education perspectives (Patel & Agbenyega, 2013), nurses experiences research (McMillen, 2008; Ward et al., 2013), and policy (Ritchie & Spencer, 1994, 2002; Srivastava & Thomson, 2009). General instructions on how to conduct framework analysis have been produced (Gale et al., 2013; Ritchie & Spencer, 1994, 2002) with worked examples published (Parkinson, Eatough, et al., 2016; Ward et al., 2013). However, to my knowledge no articles have specified how to utilise this methodology for psychology based qualitative investigations.

My research question concerns the identification of 'barriers and facilitators' with analyses pre-specified to include comparative commentary on group, interview timepoint and adherence (Boxall et al., 2022). In early discussions between myself and senior academics (K.A. and E.A.C) we debated between the use of either 'Thematic analysis' or 'Framework analysis'. These two choices arose from aims relating to the understanding of participants experience and wanting to understand their lived experiences. Therefore, a specialism focussing on experience was required. Interpretive Phenomenological Analysis (IPA) is also an experiential qualitative methodology with critical realist position however, the focus is often on more individualised experiences, using homogenous samples and smaller datasets (Braun & Clarke, 2013; J. A. Smith et al., 2009). As a target of the study was to present the experience of all participants groups and timepoints, a larger number of interviews was likely to be required. This large collection of interviews made IPA less feasible due to its focus on unique individual experiences and the lesser homogenous interview sample

datasets (Braun & Clarke, 2013; J. A. Smith et al., 2009). In comparison Framework analysis and Thematic analysis had an approach of epistemological flexibility being independent and governed more directly by the specific aims of research (Braun & Clarke, 2013; Gale et al., 2013; Ritchie & Spencer, 2002). Therefore, due to the larger data set and analyses focussing on larger group patterns, IPA was not deemed an appropriate analysis methodology.
From assessing the aims and objectives of this project Framework analysis was chosen as the best fit. This is due to its ability to interpret themes across phenomenon of interest while still being rooted in the data itself (Gale et al., 2013; Ritchie & Spencer, 2002). The aim of this work aligns with both the contextual and evaluative factors described above. For example, the question 'what are the barriers and facilitators to dietary change' refers to both the individuals experience and needs (contextual), while allowing for an understanding of the factors stopping or encouraging change (evaluative). Furthermore, this research was grounded in public health allowing for commentary on how to enhance the effectiveness of dietary guidelines (strategic) (Ritchie & Spencer, 2002).

2.4.4. Qualitative software

Once the methodology of Framework analysis was chosen, appropriate software for analysis was discussed between the PGR and supervisors (K.A. and E.A.C). The supervisor specialising in qualitative research (E.A.C) recommended the use of Microsoft Excel in the production of the framework matrix. This software was deemed appropriate for its ability visualise the charting and indexing of data in a way that was easy to manage and analyse according to published methods of undertaking framework analysis. Due to the large number of interviews conducted the PGR suggested the use of the NVivo software for the initial 'coding' of all interview transcripts. Benefits of the NVivo system include dated processing of transcripts, ease of data extraction and compatibility with 'Framework analyses' (Bonello & Meehan, 2019). The NVivo software has been widely used in peer review journals for qualitative analyses (Parkinson et al., 2016; Woods et al., 2016).

2.5. Complete study procedure

2.5.1. Trial setting

This study was based in the United Kingdom at Bournemouth University. Study recruitment was initiated in April 2021, with the first test day run in May 2021. One third of participants were recruited by September 2021 (n = 76), with their participation end date November 2021. The study was not run over the Christmas period to avoid the potential of unusual dietary intakes. The final two-thirds of participants were recruited between January 2022 and September 2022, with the final secondary test day in early December 2022. Study test days included those attending at BU food research laboratory (n = 179) and via Zoom from home (n = 63).

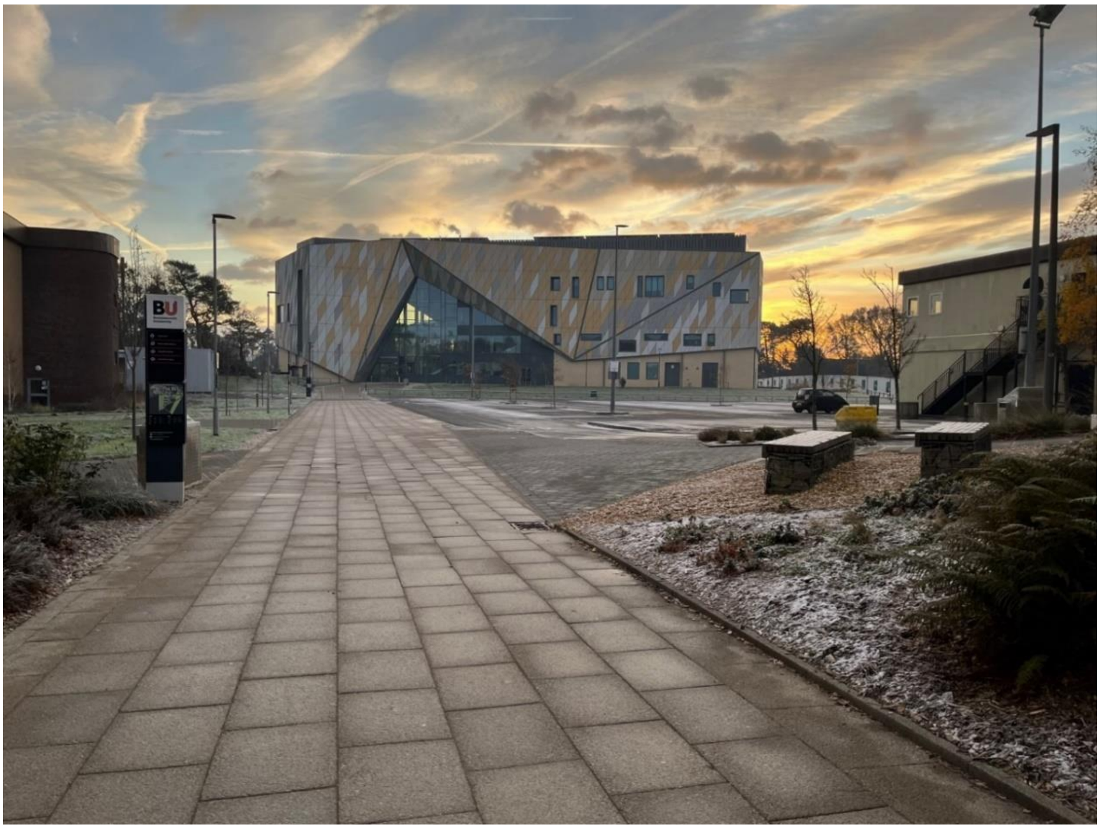

Figure 2.4: Early mornings at Bournemouth University

2.5.2. Recruitment

Participants were recruited from various sources, including local shops, cafes, restaurants, libraries, sports groups/clubs, churches, gyms, BU’s Psychology departments participant pool, online media platforms such as Facebook, and personal contacts of the PGR in the South of England. Recruitment was principally advertised using a non-coercive advertisement flyer. The complete advert example is shown in figure 2.5 below.

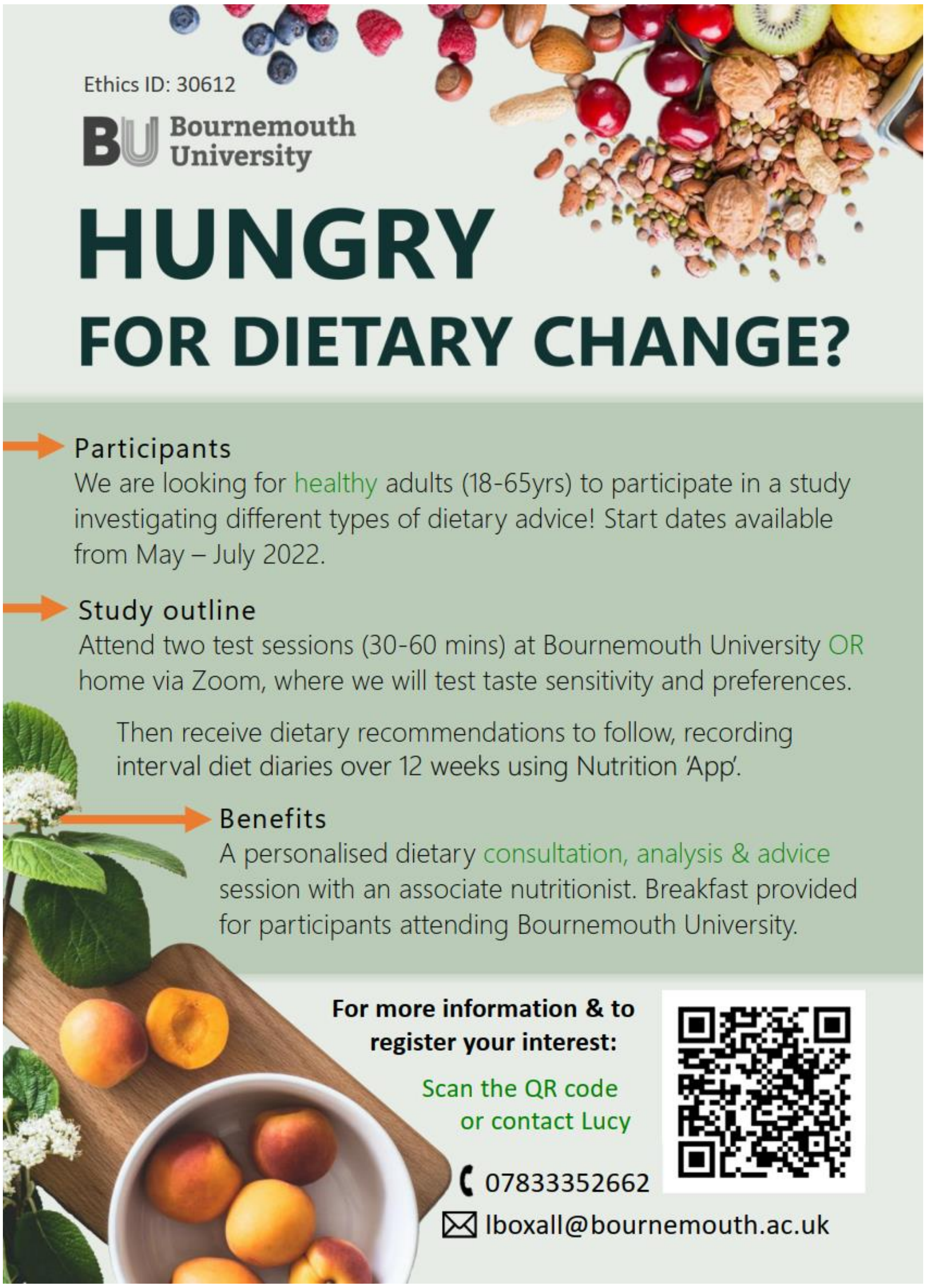

Figure 2.5: Flyer and advert used online and in person for recruitment.

2.5.3. Screening and consent

Before providing any information for the study, potential participants were provided with the participant information sheet to read (Appendix 10). If an individual wanted to participate in the study, informed written consent was gained electronically, and individuals began their eligibility screening for study inclusion. No individuals were coerced into participating, and all were provided with as long as needed to read and fully understand the participant information sheet. An initial electronic questionnaire on Qualtrics assessed all eligibility criteria excepting free sugar intakes.

Individuals eligible after initial electronic screening were provided with a Nutritics Libro (Nutritics, 2019) account and instructions on how to log their diet on the app, and invited to start the dietary screening. Dietary screening included logging 'all food and drink consumed' on the days they received a text message; these days were pre-set and provided to the participants beforehand. After completing three non-consecutive days of diet diaries (one weekend day, two weekdays), the researcher analysed this data with all those consuming over 5% of their TEI from dietary free sugars eligible for study inclusion. Potential participants were then invited to attend test day one and sent online questionnaires to complete ahead of this. As BMI formed part of the eligibility criteria, potential participants could still be excluded from study inclusion if they did not meet the abovementioned criteria.

2.5.4. Study test day

Baseline and end test day assessments lasted approximately 30–60 minutes and were conducted at Bournemouth University (BU) where possible, or in the participant's home via Zoom. 'At-home' test sessions were used if participants were unable or unwilling to come to the University and were intended primarily to allow the trial to continue during the COVID-19 pandemic due to National lockdown measures in the UK (March 2020 - July 2021). These home test sessions also opened the trial to participants who would otherwise be unable to participate, enhancing study inclusivity. Participants were tested in the same location at baseline and trial end, as far as possible. Individuals taking part from home were posted materials for the test day ahead of time (Boxall et al., 2022).

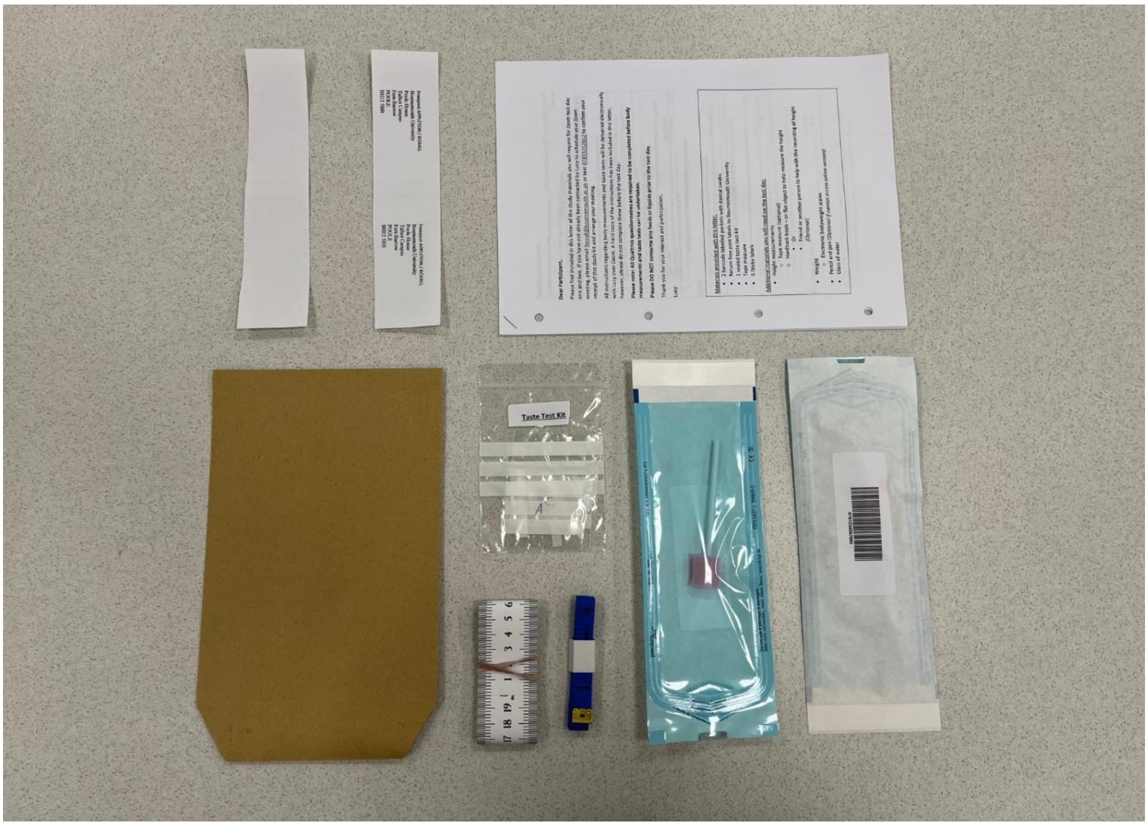

Figure 2.6: Materials posted for home test days

All participants completed the same measures regardless of their completion of test sessions at BU or at home, with a few exceptions: Participants who were tested at home did not undertake the solution-based measure of sweet liker status. Participants tested at home also completed their own anthropometric measurements while the trial researcher (LRB) observed via Zoom. Comparability across measurements was facilitated by the involvement of the same researcher, whether at the University or home, and was investigated once the trial had been completed (Boxall et al., 2022).

All sessions commenced before 11 a.m. to allow individuals to undertake the measures in a fasted state, and began at the same time at baseline and trial end, as far as possible. The day before testing, participants were asked not to consume any alcohol, to consume nothing after 10 p.m., and not to undertake heavy exercise. Measures were undertaken in the same order during each test session, as follows, or omitted due to consent: anthropometry, saliva sample, sweet liker status, and PROP taste test. All participants' questionnaires were checked for completion before the test session. Incomplete questionnaires were completed on the test day. Missing diet diaries throughout the trial resulted in an automatic text reminder. This reminder asked participants to complete the diaries but did not refer to dietary recommendations (Boxall et al., 2022).

2.5.5. Researcher reflection two

The set-up and running of this RCT trial were a new exploration for me as a researcher. Due to my initial inexperience the decision with my supervisor was taken for me to produce a procedural guide. This was to ensure that all decisions taken, and processes completed were of the highest academic standards. These documents are included in my thesis in appendices 5-9 and were a valuable reference to have during the running of my study. Although the write-up of the material went smoothly the implementation of them did not. This was due to COVID-19 and the decision I had to make on which route to take my PhD journey on. Did I pause my research? Or completely redesign my PhD? With careful discussions and personal reflection, I made the decision to interrupt my study. This decision was taken as primarily I believed in the value of the research. I did not want to abandon the study for something I believed would not have been as progressive for myself or its real-world impact.

2.5.6. Withdrawal and debriefing

Participants were considered as having withdrawn from the trial if they either requested to withdraw or completed less than two of the three final diet diaries. If individuals failed to complete diet diaries during the trial, they were sent reminders with data noted as 'missing' while the participant continued in the trial (Boxall et al., 2022).

Individuals were debriefed on exit or at their original 12-week intervention endpoint. During the debriefing session, participants were asked if they experienced any adverse events during or caused by the study and their understanding of the trial's purpose. Participants were then debriefed regarding the true purpose of the trial. Following the debrief session, participants were offered a diet consultation by a Registered Associate Nutritionist (LRB) as a thank-you for participating (Boxall et al., 2022).

2.5.7. Research assistants' contribution

Two research assistants (RA) contributed to the practical running of the research project for a maximum of 4 hours per week between March 2022 – July 2022. All responsibilities were overseen by the primary research (PGR, LRB). Test day responsibilities included collecting participants from reception, help with weighing of food items once eaten, washing up, measuring paper VAS lines, and entering VAS line measurements into excel. One RA conducted a leaflet drop near Bournemouth University and another RA completed comparable advertisement by posting the project in Facebook groups online. A unique QR code was provided to each RA to track if any recruitment resulted in participant enrolment. Less than 1% of participants recruited were done so by the RA's. The primary researcher (LRB) attended all in person and zoom test days; recruited all other participants (>99%), set up designed and ran all other research activities from data collection, analysis and writeup for the remainder of the study unless otherwise specified.

2.6. Overview of analyses

The data gathered contributed to three distinct analyses: 1) Analyses of the population as a whole to investigate the effects of the three different dietary recommendations versus control; 2) Analyses of the effects of the dietary recommendations in different population subgroups, and 3) Investigation of the barriers and facilitators to success (Boxall et al., 2022). Statistical analysis of quantitative data was completed using the Statistical Package for the Social Sciences (SPSS) statistics software (IBM, 2021) , and analysed on an intention-to-treat basis. Data was checked for normal distribution and presented as mean ± standard deviation (SD) to 2 decimal places. Data is considered statistically significant at $p<0.05$. A variety of statistical tests were carried out for each analysis including, descriptive statistics, t-tests, ANOVAs, Pearson correlations and multiple linear regressions (further details are outlined in chapter 3).

2.6.1. Mixed method data analysis

This study utilised a mixed method approach in the assessment of the effectiveness of recommendations to reduce free sugar intakes. The quantitative aspect addressed objective changes in free sugar intakes and adherence to recommendations. The quantitative data provided the statistical objective evidence for if dietary change had occurred. However, having only the quantitative data would not tell us about the experiences of participants in undertaking the dietary intervention. Therefore, qualitative investigations allowed a depth to quantitative findings (Bazen et al., 2021). The combination of these two approaches in a mixed method design was important to address not only the primary aim but also the tertiary supporting outcomes relating to participant experiences, something that could not be done in one approach alone (Schoonenboom & Johnson, 2017; Shorten & Smith, 2017; Wasti et al., 2022). For a sub-set of interviewed participants, quantitative and qualitative data was collected concurrently across the 12 weeks. The qualitative data was analysed using FA. Integration of these methods occurred at data interpretation, where specific quantitative findings were mapped to the qualitative matrix to provide a deeper understanding (Schoonenboom & Johnson, 2017; Shorten & Smith, 2017). In choosing to do a mixed methods approach, Framework analysis could be used to produce meaningful discussion surrounding the experience of participants interviewed from different groups; timepoints; and adherence scores. This combination allowed for a greater understanding of the barriers and facilitators experienced across these key factors and has been utilised in comparable research on healthy eating (Snuggs et al., 2023). Furthermore, the mixed method approach allows the strengths of both approaches to be leveraged against one another to mitigate weaknesses in single approaches (Bazen et al., 2021; Verhoef & Casebeer, 1997).

2.6.1. Quantitative research data handling

All Information gathered from participants for this study at an individual level was anonymised. Before individuals could progress into the main study, their baseline dietary free sugars were assessed using the Nutritics Software (Nutritics, 2019b). This eligibility for the study was completed remotely before participants were invited to attend the first 'test day'. During this initial data gathering, dietary information was only collected to screen an individual's TEI of dietary free sugars. This data was only kept and assimilated into the main study if the potential participant was eligible for study inclusion. All diet diaries and other measures during the study intervention were recorded remotely via the Nutritics Software (Nutritics, 2019b).

All dietary data collected using Nutritics was initially recorded on Nutritics (Nutritics, 2019b) encrypted cloud-based storage (Nutritics, 2019b). Once individuals had completed the study intervention period, their data was downloaded from the Nutritics (Nutritics, 2019b) cloud database and stored in the student H drive. Where individuals provided additional consent for an audio-recorded interview, once transcription of the audio file had been completed, the original audio file was disposed of and the transcription immediately anonymised. All other participant data gathered from the study was also stored on the student H drive. This data is only accessible to the PGR researcher Lucy Boxall, and the main study supervisor, Katherine Appleton. The data gathered in this study may be stored for 5 years after the degree award or after the publication of the data, whichever time is later. After this, data will be securely destroyed by complete removal from the student H drive following BU's Research Ethics Code of Practice guidelines.

2.6.2. Dietary data preparation

Dietary analysis could begin once all diet diaries were received, with the researcher still blinded to intervention allocation. All participant diet diaries were exported from the Nutritics database. Then all unique foods logged by all participants were exported into a secondary spreadsheet. As some of Nutritics food database has incomplete data for free sugars, all foods were checked individually for missing data. All foods that were complete or likely to not contain free sugars e.g., 'Sainsburys frozen broccoli', maintained their original codes. Where foods contained incomplete free sugar data e.g., 'Cadburys mini eggs' that food was substituted with a corresponding food item with complete data for free sugars e.g., 'Cadburys milk chocolate'. Following the creation of the food substitution file, all foods needing to be replaced across all diet diaries (baseline – endpoint) were undertaken. Totals for each diet diary day were then calculated as summated into their respective time points, baseline (DD -1 to -3), timepoint one (DD 1-3); two (DD 4-6); three (DD 9-11); four (DD 13-15) and endpoint (last 3 DD 19-21). Completing the dietary analysis this way ensured all participants at all timepoints were treated the same. Further details are included in Appendix 11.

2.6.3. Multiple imputation

Main analyses were completed on an intention-to-treat basis as the gold standard for representing the intervention's applicability in a real-world setting rather than an ideal outcome. A variety of techniques to analyse RCT results with missing data have been previously utilised, including complete case analysis (CCA), single imputation (SI)(by last observation carried forward, mean or regression), multiple imputation (MI) or mixed-effect models (Bell et al., 2014; Ren et al., 2022). In the comparison between methods, multiple imputation is recommended due to the large dataset analysed and its greater ability to provide unbiased estimates of missing data (Li & Stuart, 2019).

Instructions for the steps used to complete MI and the imputation sequence are included in Appendix 12. As multiple imputation is completed in the order of the variables within the analysis, the variables list was set as randomisation variables first, then nutrient values, anthropometrics, and finally questionnaire data in the order that they were completed. All baseline variables were used as predictors, and all endpoint variables were used as imputations only due to the monotonic pattern (IBM, 2023).

Current literature suggests the optimal number of imputations varies between 5-20, with a limited benefit over 5. Additional literature supports the number of imputations matching the percentage of attrition. Therefore, the number of imputations for the main analyses was set at twenty, representing both the upper recommendation and percentage attrition (Buuren, 2018; Heymans & Eekhout, 2019).

Updates to SPSS now allow random selection of the closest imputed match from more than 1 donor (IBM, 2023). Existing methodology and the number of imputations suggest imputations via predictive mean matching (PMM) are selected from the five closest donors, making this more statistically robust than previous methods (Buuren, 2018; Heymans & Eekhout, 2019).

Before completing multiple imputation, the pattern of missing data was checked. Endpoint data presented as missing in a monotonic pattern. When imputing missing data values in SPSS the custom 'fully conditional specification' (FCS) in methods was selected over monotone. This was because FCS is suitable for both monotone and non-monotone patterned data and introduces Bayesian stochastic regression imputation as part of the predictive means multiple imputation methods. The benefit of this method results in imputed data being taken from both a donor and then adjusted to introduce a level of variability rather than just a copied result. Maximum iterations were set as fifty, with FCS convergence checked post-imputation. For all applicable statistical tests, analyses were run on each imputed dataset, with values pooled post-analysis. This is because a pooled dataset prior to analysis represents the average and retains the variability of the individual imputed datasets (Buuren, 2018; Heymans & Eekhout, 2019).

Where SPSS did not automatically pool results, Rubin's Rules for combining single estimates were used (Marshall et al., 2009).The same multiple imputation guidelines were used for the basis for the imputation of all missing data. Where variables presented as having missing data, they were set as 'impute only' to ensure all predictor variables were not based on imputed data. The only difference was in that one baseline waist circumference value that was missing in the original data was used in the 2nd MI predictors of the subsequent variables. This study did not generate imputations based on imputed data values. The same multiple imputation model was run for the initial analyses, adherence and variables completed by only lab participants. Multiple imputation for the adherence data used the same methods and predictors as the MI PMM for the main data set. The step-by-step methods used are included in Appendix 12. Adherence data points of each free sugar intake at each dietary data point were not included as predictors since at least one timepoint needed to be imputed at each variable time point.

2.6.4. Conditions revealed.

After MI was completed, a full dataset was emailed to another researcher to allocate the intervention grouping variable. The main researcher (LRB) had no knowledge of allocated groups of participants before receiving the dataset and was blinded up to this point.

2.6.5. Analyses one: Effects of the different dietary recommendations

To test the effects of the different dietary recommendations, a series of multiple regression analyses were run. A separate analysis was run for each outcome variable, where the outcome at week 12 was predicted by trial arm (intervention/control) and outcome variable at baseline. Additional independent variables were also included in each analysis as appropriate (Boxall et al., 2022). Model one multiple regression analyses were completed in the whole dataset.

2.6.6. Analyses two: Effects in different population subgroups

The above analyses were repeated in specific population groups, assuming appropriate numbers, based on demographic variables and other variables identified as important in analyses one (Boxall et al., 2022).

2.6.7. Analyses three: Barriers and facilitators toward dietary change

Qualitative data was transcribed and analysed using framework analysis (Braun & Clarke, 2006, 2013; Gale et al., 2013) as described below. These analyses were aided by the use of NVIVO software and reported using the Consolidated Criteria for Reporting Qualitative Research (COREQ) (Tong et al., 2007). Categories were gained from the population as a whole at different time points and interpreted in combination with the data on free sugar intakes and adherence. Once themes from the data emerged, each will be discussed relating to that specific area of literature. Discussions also refer to data recorded at different time points, intervention groups, and adherence levels (Boxall et al., 2022).

2.6.8 Undertaking Framework analysis.

The following section outlines the methodological steps undertaken at each stage of the Framework analysis. Where additional researchers contributed to double coding or validation of findings this has been stated.

Framework analysis (Braun & Clarke, 2006, 2013; Gale et al., 2013)

Phase 1 'Familiarizing yourself: Transcribing data (if necessary), reading and re-reading the data, noting down with your data: initial ideas'. (Braun & Clarke, 2006, 2013; Gale et al., 2013)

- Audio data was transcribed, using automated timestamps and a published notation system (Braun & Clarke, 2013) in NVivo software (Lumivero, 2023) (version 14).
- To ensure high quality audio and transcription practises, Poland's '*Strategies for Ensuring High-Quality Tape Recording'* were used (Poland, 2001; Poland & Poland, 1995).
- Interviews were transcribed to produce a verbatim account. Data was re-read and checked to ensure accurate transcription. Once the transcription was completed data was anonymised and the audio file destroyed.

Phase 2 'Generating initial codes: Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.' (Braun & Clarke, 2006, 2013; Gale et al., 2013)

- Using a process of complete coding (Braun & Clarke, 2013) initial codes were generated after the transcription of the first 12 interviews.
- The data set was only be considered saturated once fewer than 5% of new codes were identified in ongoing analyses. Two additional transcripts were required at this point to confirm saturation (Ando et al., 2014; Guest et al., 2006; Hennink et al., 2017; Lowe et al., 2018; Saunders et al., 2018).

- Once saturation was confirmed (Ando et al., 2014; Guest et al., 2006; Hennink et al., 2017; Lowe et al., 2018; Saunders et al., 2018), inter-rater reliability (McHugh, 2012) was tested.
    - Four randomly (computer generated number selection) selected transcripts and the coding book (Boyatzis, 1998; K. Roberts et al., 2019) were provided to the lead supervisor (K.M.A) for this test.
    - Only once substantial coding agreement between the PGR and lead supervisor (K.M.A) was achieved (κ = >0.61) (McHugh, 2012) could phase 3 begin.

Phase 3 'Developing a working analytical framework.' (Gale et al., 2013)

- After reaching saturation as agreed above, the researchers met (L.R.B and K.M.A) and agreed the codes for all subsequent transcripts. These codes were then grouped together into categories or themes by LRB (Gale et al., 2013).

Phase 4' 'Applying the analytical framework' (Braun & Clarke, 2006, 2013; Gale et al., 2013)

- All transcripts were coded according to the agreement in phase 3.
- All candidate themes were reviewed and checked with the lead supervisor (KMA) and a secondary qualitative specialist supervisor (EAC) to ensure a coherent theme pattern was present.
- The whole data set was reviewed providing answers to these questions.
    - Do the themes work in relation to the whole data set?
    - Does any re-coding of data within themes need to be completed?
    - Has anything been missed from the initial coding?

Phase 5 'Charting data into the framework matrix' (Gale et al., 2013)

- Data from transcripts was charted into an excel spreadsheet outlining each interview and the extracted quotes (and location reference) for each code.
    - Summaries were then created for each participants commentary across all themes and subthemes.
    - A further set of summaries were created across group, interview timepoint and summative adherence to assess variation(Goldsmith, 2021). This data is shown in summaries provided in the qualitative results section of chapter 4.

Phase 6 'Interpreting the data' (Gale et al., 2013)

- Connections between relationships and categories were mapped. (Gale et al., 2013).
- Characteristics and variations between groups, interview timepoints and summative adherence was analysed.
- A 15-point check list from Braun and Clarke (Braun & Clarke, 2013) and the Consolidated Criteria for Reporting Qualitative research (COREQ) (Tong et al., 2007) checklist was used in the write-up and reporting of this qualitative research.

Researchers and Reflexivity

The PGR (LRB) and secondary coder (KMA) were both female, with a healthy BMI, and had been involved with projects regarding dietary sweetness. The two researchers had backgrounds in nutrition, psychology and eating behaviour, with no history of mental or physical eating disorders or conditions. Neither researcher held strong opinions regarding current dietary trends. The researchers were not following any specific dietary programmes during the course of the research or at the time of analyses and dissemination. The secondary coder (KMA) was the primary supervisor of (LRB) which could have impacted bias, however due to the coding methodology this was unlikely. The PGR (LRB), interviewed, transcribed and coded all interviews, completing all qualitative analyses as specified above. The transcribing author (L.R.B) developed the codebook in agreement with a second author (K.M.A) who doubled coded 10% of the 62 transcripts for 100% agreement.

3. Quantitative results

This results section presents analyses of collected data addressing the research questions and objectives outlined in chapter one. Initial statistical tests and participant characteristics are presented first, followed by analyses one (primary outcome) and two (secondary outcomes) of quantitative data. In exploratory analyses, only significant findings are reported in this chapter, with non-significant test results shown in Appendix 13. Data presented in this chapter utilised an intention-to-treat treat-protocol with missing data estimated from multiple imputation. All analyses were repeated in CCA, with these results included in Appendix 14. Commentaries on any differences with the CCA are included in this chapter's writeup. All data was processed, analysed and written up by the PGR (LRB).

3.1. Data presentation

Data are presented as mean ± standard deviation unless stated. Values are considered significant at the $p<0.05$ level. Before completing analyses, data was checked for normality. Shapiro Wilk tests for normality were used; however, in tests with $n > 30$ in each group, data was treated as having assumed normality due to the large sample size ($N = 242$) and central limit theorem (Wackerly et al., 2008). Where assumptions of homogeneity of variance were violated (Levene's test $p<0.05$), statistics were taken from analyses assuming non-equal variances. Bonferroni corrections for multiple tests were applied to data where tests had not been pre-specified in the study protocol. Where multiple regression analyses were used, all variables were checked for multicollinearity, and all included variables in models were correlated to <0.7. Pearson correlation values were used on all continuous variables, and spearman correlations for categorical variables. Where analyses have been completed in the whole population and intervention-only subgroups, the name of the analyses will be followed by "All", or "IV", respectively.

3.2. Enrolment and attrition

Overall, 1,147 individuals registered their interest on Qualtrics for the dietary study, of whom 538 completed the initial characteristic screening and the consent form. These 538 individuals were invited to complete the last eligibility stage, dietary screening. This resulted in 242 participants who were randomly allocated to 4 trial arms. Attrition at the study end was 42 participants or 17.5% dropout.

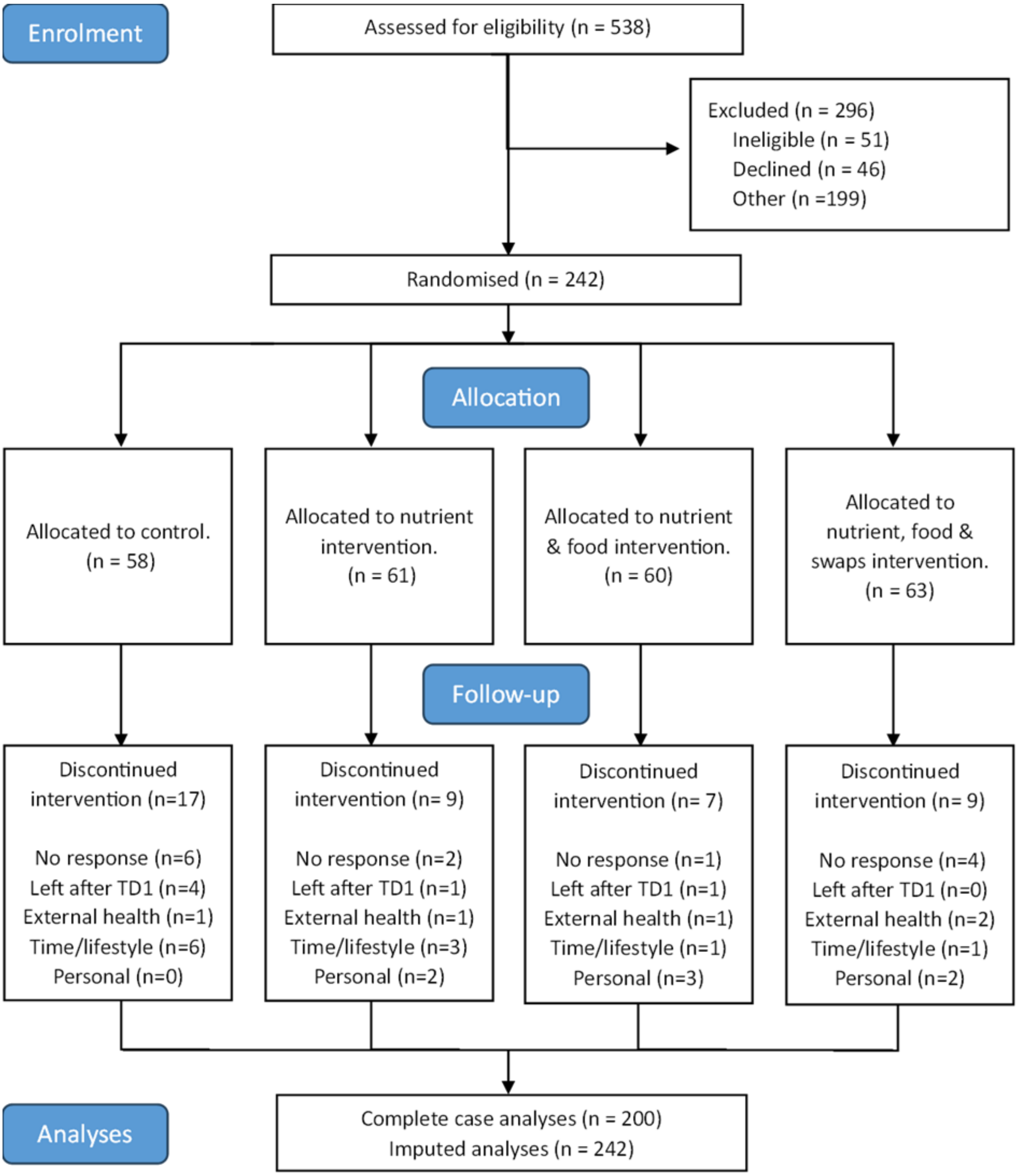

Figure 3.1: CONSORT flow diagram to show flow of participants through the trial from Test day 1 (TD1), (when all participants allocated to trial arms received their intervention booklet and study advice)

3.2.1 Researcher reflection three

The journey to the point of data analysis felt long, but also went quickly, marked by the most substantial growth in my personal confidence. The initial set-up of the study was daunting, *but nothing compared to the prospect of needing to recruit at least 240 individuals for this research. Initial comments from some family and friends were concerned at what lay ahead which in the beginning affected my confidence. This combined with the study having a slow screening process to enrolment meant initial numbers were low for the beginning months of recruitment – it was a worrying time for me. Sometimes it felt like I would never hit the numbers required as individuals could withdraw interest at any time and participation was never a guarantee. I have been asked what I did to help with this, and the answer is perhaps boring in that I doubled down on the work I put into recruitment. Within the time I had, I posted daily adverts, delivered flyers, contacted sports clubs and utilised university resources wherever I could. At the end of the first year, I had recruited 90% of my goal for that time period and felt confident going into the final study recruitment during 2022 that it would be possible – and it was! I recruited all the participants required for my research within the time frame something I hadn't really accepted until it became a reality. I was both elated and relieved.*

3.3. Participant characteristics

Participants included 214 women and 28 men from the south of England. Most participants were Caucasian British, the main cook (78%), educated to degree level or higher (62.8%), had "sufficient" income levels (89.7%) and were over 40 years of age (54%) with 16.1% being under 25 years. Religious dietary impacts were unlikely to impact the study with less than 1% participants stating a potential impact during their 12-week participation. The average BMI was 27.72±5.73 kg/m2, with even proportions in the lean, overweight, and obese BMI categories, 35.1, 35.1 and 29.8% respectively. The demographics discussed here are shown in table 3.1 as separated by group.

Table 3.1
Baseline demographic table

		Control (58)	N (61)	NF (60)	NFS (63)
Age		41.72 ± 12.55	42.39 ± 14	38.33 ± 12.15	42.51 ± 13.41
Gender:	Male	5	7	8	8
	Female	53	54	52	55
Ethnicity					
	White, UK	51	53	50	58
	Other background	7	8	10	5
Occupation					
	Long term unemployed	6	3	6	5
	Routine	6	4	5	6
	Semi-routine	1	5	2	7
	Lower supervisory	2	3	3	4
	Small employers	4	2	1	1
	Intermediate	10	5	8	3
	Lower managerial,	18	27	27	28
	Higher managerial	11	12	8	9
Nationality					
	British	53	56	53	59
	British/other	0	2	2	1

Table 3.1
Baseline demographic table

		Control (58)	N (61)	NF (60)	NFS (63)
	Other	5	3	7	3
Education					
	Other	1	3	2	1
	Secondary school	2	3	4	5
	College level	21	17	12	19
	Undergraduate degree	20	23	28	26
	Postgraduate and >	14	15	14	12
Income level					
	Very insufficient	0	0	0	2
	Insufficient	3	8	4	8
	Sufficient	55	53	56	53
Diet-type					
	Other	3	5	3	1
	Vegan	3	1	1	1
	Vegetarian	7	7	12	6
	Omnivore	45	48	44	55
Main cook					
	Yes	50	48	43	48
	No	8	13	17	15
Religion affects					
	Yes	2	0	0	0
	No	56	61	60	63
FS%		10.36 ± 5.1	10.13 ± 5.15	10.68 ± 4.78	10.19 ± 4.42
Energy (kcal/day)		1782 ± 538	1726 ± 503	1773± 477	1683 ± 436
Sugars (g/day)		78.1 ± 28.8	74.34 ± 27.75	72.8 ± 32.16	71 ± 30.04
Free Sugars (g/day)		46.11 ± 26.17	43.06 ± 23.54	47.75 ± 25.35	42.03 ± 19.16
BMI (kg/m2)		27.51 ± 5.84	27.45 ± 5.73	28.5 ± 5.87	27.44 ± 5.56
Height (m)		1.67 ± 0.07	1.68 ± 0.08	1.68 ± 0.08	1.67 ± 0.08
Weight (kg)		76.67 ± 16.7	77.36 ± 18.71	81.16 ± 18.47	76.21 ± 16.32
Waist circumference (cm)		87.43 ± 12.23	89 ± 14.87	90.54 ± 17.41	88.38 ± 12.81

Mean ± standard deviation, participant numbers in parentheses. Total energy intakes of free sugars (FS%), body mass index (BMI), Nutrient (N), nutrient & food (NF), nutrient, food & swaps (NFS).

3.4 Data preparation

3.4.1. Lab vs Home

Before imputation and primary analyses could be completed, an independent t-test was run to assess differences in baseline variables between those who took part from home (n=63) or at BU (n=179). This test found that out of the 63 variables included and after Bonferroni corrections, only taste paper A (TPA) liking was significantly different, mean difference 11.0 ± 41.4 ($t(240) = 4.12$ $p<0.001$), between lab (52.1 ± 18.4) and home (63.1 ± 17.7) groups.

3.4.2. Sweet liker

Classification of sweet liker status uses 1M sucrose liquid. Measures in the lab (N=179) for sweet liking used sucrose liquid 'A' (TLA) and sucrose taste paper "A" (TPA). To calculate TLA scores for the home group, TPA home scores needed to be corrected, accounting for the significant difference between the means for the lab and home group. Standard deviations were comparable. Percentage corrections were calculated using the following equation ((TLA mean – TPA mean)/TPA mean) x 100 = Y. To approximate liking of TLA scores for participants at home (N=63) (home 63.1 ± 17.7, lab 52.1 ± 18.4) a correction factor of -3.34% for liking of TPA was used. Post correction an independent t-test was run on the TLA variables to assess differences between the home and BU groups. Levene's test was violated ($p<0.001$) with a significant mean difference 10.64±36.37, t (160.78) = 3.71, $p<0.001$) between the groups, (home 61.03±17.12 and BU 50.39±25.29).

3.5. Analyses one

3.5.1. Primary analyses

Four multiple regressions were run to predict the following outcomes: endpoint free sugar intakes % (FS%), endpoint bodyweight (kg), endpoint waist circumference (cm) and endpoint total energy intake (kcal). This includes the primary outcomes of FS% at week 12(FS1), with adherence discussed after model 1 regression analyses.

The following variables were included in each of the multiple regression models:

- FS1 - Endpoint free sugar intakes
    - Group, baseline FS%, baseline bodyweight, gender, age, endpoint physical activity and endpoint total energy.
- BW1 - Endpoint bodyweight
    - Group, baseline FS%, baseline bodyweight, gender, age, endpoint physical activity and endpoint total energy.
- WC1 - Endpoint waist circumference
    - Group, baseline FS%, baseline waist circumference, gender, age, endpoint physical activity and endpoint total energy.
- TE1 - Endpoint total energy
    - Group, baseline FS%, baseline total energy, gender, age, endpoint physical activity and endpoint bodyweight.

3.5.1.1. Baseline ANOVA

A one-way ANOVA was run to determine if there were any differences between groups at baseline. Participants were separated into four groups: control, N, NF and NFS. Allowing for Bonferroni corrections, no significant differences were found between the groups.

3.5.1.2. Multiple regression one

***$FS1_{All}$* -** Endpoint FS% was significantly predicted by the regression model, $F(7,234)=8.66$, $p<0.001$, $R^2=0.21$, adj $R^2=0.18$, with group (b=-0.636, p=0.03), baseline FS% (b=0.377, p<0.001) and baseline bodyweight (b =-0.04, p=0.04) variables adding statistically significantly to the prediction. The mean FS% reduced in all intervention groups N, NF, and NFS by 2.47%, 3.25%, and 3.08%, respectively, compared to no change in the control group -1.18%.

***$BW1_{All}$* -** Endpoint bodyweight was significantly predicted, $F(7,234)=1214.91$, $p<0.001$, $R^2=0.97$, adj $R^2=0.97$ with only the baseline bodyweight (b=0.953, p<0.01) variable making a statistically significant contribution to the prediction. There was a weak association between endpoint bodyweight and group (b=-0.36, p=0.06 (marginal significance). The mean endpoint body weight reduced in all intervention groups N, NF, and NFS by 0.72kg, 1.44kg, and 1.11kg, respectively, compared to no change in the control group -0.17kg.

***$WC1_{All}$* -** Endpoint waist circumference was significantly predicted, $F(7,234)=198.19$, $p<0.001$, $R^2=0.85$, adj $R^2=0.85$. Only baseline waist circumference (b=0.902, p<0.01) added statistically significantly to the prediction. The mean endpoint waist circumference reduced in all groups N, NF, NFS, and control by 1.3cm, 2.8cm, 1.85cm and 0.44cm, respectively.

***$TE1_{All}$* -** Endpoint total energy was significantly predicted, $F(7,234)=8.97$, $p<0.001$, $R^2=0.21$, adj $R^2=0.19$ with only the baseline energy adding significantly (b=0.362, p<0.001) to the prediction. The mean endpoint total energy reduced in all groups N, NF, NFS, and control by 215, 307, 188 and 266, respectively.

Pairwise baseline to endpoint investigations

A pre-post intervention paired t-test for the outcomes of regression analyses one was run. This test further supported regression one's findings by investigated changes across all groups. The outcomes FS% and TE were included to explore if participants all reduced reported TE intakes and the significance of group in FS1. Bodyweight and waist circumference were included due to marginal findings by group in the BW1 supported by the significant finding in the CCA of BW1 (Appendix 14). After Bonferroni corrections, the following significant differences were found. First, In all groups, total energy intakes significantly decreased from baseline to endpoint. Second, all intervention groups (but not the control) showed a significant decrease in FS%. Third, the NF group significantly reduced their waist circumference and body weight. All effect sizes and significance levels are reported in table 3.2.

Table 3.2

Pairwise comparisons, decreases from baseline to endpoint

	Control	N	NF	NFS
FS%	-1.18 ± 5.97 (0.20)	-2.47 ± 5.94*(0.42)	-3.25 ± 5.81** (0.56)	-3.08 ± 5.31** (0.58)
WC	-0.44 ± 8.11 (0.05)	-1.34 ± 5.09(0.26)	-2.8 ± 6.46* (0.43)	-1.83 ± 6.27 (0.29)
BW	-0.17 ± 3.18 (0.05)	-0.72 ± 2.99(0.24)	-1.44 ± 3.62* (0.40)	-1.11 ± 3.58 (0.31)
TE	-266 ± 598** (0.45)	-215 ± 491**(0.44)	-307 ± 460** (0.67)	-188 ± 543* (0.35)

Footnotes: Bonferroni corrections Cohens effect size in brackets. Significant to <0.05 *, significant to <0.01**. Waist circumference (WC) in cm, bodyweight (BW) in kg, total energy (TE) in kcal. Nutrient group (N), nutrient and food group (NF), nutrient, food and swaps group (NFS).

Intervention group multiple regression

To support earlier findings a repeat of the multiple regression models in analyses one was run for only the intervention groups, N, NF and NFS.

***FS1$_{IV}$* -** Endpoint FS% were significantly predicted, $F(7,176)=5.56$, $p<0.001$, $R^2=0.18$, adj $R^2=0.14$, with only baseline FS% ($b=0.356$, $p<0.001$) adding statistically significantly to the prediction. There was no association between endpoint FS% and group. The mean FS% reduced in all intervention groups N, NF, and NFS by 2.47%, 3.25%, and 3.08%, respectively.

***BW1$_{IV}$* -** Endpoint bodyweight was significantly predicted, TE, $F(7,176)=930.80$, $p<0.001$, $R^2=0.97$, adj $R=0.97$ with only the baseline bodyweight($b=0.937$, $p<0.01$) variable adding significantly to the prediction. There was no association between endpoint bodyweight and group. The mean endpoint body weight reduced in all intervention groups N, NF, and NFS by 0.72kg, 1.44kg, and 1.11kg, respectively.

***WC1$_{IV}$* -** Endpoint WC was significantly predicted, $F(7,179)=193.04$, $p<0.001$, $R^2=0.88$, adj R2=0.88. Only the baseline waist circumference variable ($b=0.889$, $p=0.001$) added statistically significantly to the prediction. The mean endpoint waist circumference reduced in all intervention groups N, NF, and NFS by 1.3cm, 2.8cm, and 1.85cm, respectively.

***$TE1_{IV}$* -** Endpoint total energy was significantly predicted, $F(7,176)=8.97$, $p<0.001$, $R^2=0.26$, adj $R2=0.23$ with only the baseline total energy adding significantly ($b=0.428$, $p<0.001$) to the prediction. The mean endpoint total energy reduced in all groups N, NF, and NFS by 215, 307 and 188 (kcal), respectively.

3.5.1.3. Adherence

Adherence was classified at five-time points across the 12-week intervention. The scores for these values are shown in table 3.3. Adherence counts were greater in all intervention groups at timepoint one than timepoint five. Due to low numbers to the answer 'NO' to whether participants were following the recommendations, the groups "passive adherent" and "active non-adherent" had fewer numbers. Therefore, adherence at time points 3-5 for further analyses used only adherent/non-adherent categorisation (as did time points 1 and 2). Results for adherence from this point are discussed with only the adherent/non-adherent categories, and no passive or active categorisation is used.

Table 3.3
Passive and active adherence classification

		Adherent		Non-adherent	
		Active	Passive	Active	Passive
Timepoint 3	Control	26	1	3	28
	N	38	3	7	13
	NF	35	2	2	21
	NFS	40	1	4	18
Timepoint 4	Control	25	3	2	28
	N	35	5	5	16
	NF	34	6	0	20
	NFS	41	5	3	14
Timepoint 5	Control	23	1	3	31
	N	33	4	8	16
	NF	36	3	4	17
	NFS	33	6	3	21

Pooled frequencies are presented in this table. Control group, nutrient group (N), nutrient and food group (NF), Nutrient, food and swaps group (NFS). Timepoint 3 (week 4), Timepoint 4 (week 8), timepoint 5 (week 12). Adherent categorised reduced intake of free sugar % intakes by >2% or achieved <5% intakes. Non adherent categorised did not achieve this.

A chi-square test of independence was run to test associations between adherence and group across the five time points. All cell frequencies exceeded five. At time point one, there was a significant association between group and adherence $\chi^2(3) = 12.43$, $p<0.01$. The association was moderately strong (Cohen, 1988), Cramer's V = .226. All other time points (2-5) had non-significant associations between group and adherence.

Table 3.4

Crosstabulation of group and adherence counts across time points.

	Adherent					Non-adherent				
TP	1	2	3	4	5	1	2	3	4	5
CG	27 (-3.27)	29 (-1.43)	27 (-2.54)	29 (-2.6)	24 (-2.81)	31 (3.27)	29 (1.43)	31 (2.54)	29 (2.6)	34 (2.81)
N	40 (0.06)	35 (-0.01)	41 (1.2)	40 (0.47)	37 (0.64)	21 (-0.06)	26 (0.01)	20 (-1.2)	21 (-0.47)	24 (-0.64)
NF	46 (2.1)	37 (0.78)	38 (0.46)	40 (0.43)	39 (1.37)	14 (-2.1)	23 (-0.78)	22 (-0.46)	20 (-0.43)	21 (-1.37)
NFS	45 (1.05)	38 (0.63)	41 (0.86)	46 (1.65)	39 (0.75)	19 (-1.05)	25 (-0.63)	22 (-0.86)	17 (-1.65)	24 (-0.75)

Pooled frequencies are presented in this table. Timepoint (TP), control group (CG), nutrient (N), nutrient and food (NF), nutrient food and substitution (NFS). Adjusted residuals are shown in parentheses below frequencies. Adherent categorised as reduced intake of free sugar % intakes by >2% or achieved <5% intakes. Non adherent categorised did not achieve adherent boundaries.

3.5.1.4 Summary finding: Analyses one

- In FS1, endpoint FS% at week 12 was significantly predicted by group, baseline FS% and baseline bodyweight. This represented a reduction in FS% in all intervention groups from baseline. There were significant differences between baseline and endpoint FS% in all intervention groups but not the control group.
- In BW1, endpoint BW at week 12 was significantly predicated by baseline bodyweight with marginal significance from group.
- In WC1 and TE1, only the baseline predictors of waist circumference and total energy contributed to the regression models respectively.
- Adherence categorisation by active or passive did not show overwhelming trends. The Chi square demonstrated a significant association between group and adherence at timepoint 1, all other timepoints were non-significant.

3.5.2. Further analyses

For further analyses the four multiple regressions models in analyses one for outcomes: endpoint FS%, endpoint bodyweight, endpoint waist circumference and endpoint total energy were repeated. First, four correlation models were run to assess associations between the main outcomes and secondary study variables at baseline. Spearman correlations were used where categorical variable were tested and are highlighted in results tables using a $ symbol. Where no symbol is given Pearson correlations were run. Participants attending BU undertook additional taste tests. Where all participants undertook all measures, they are analysed as the whole study population. The following correlation models were used:

- Attitudes and behaviours **(All)**
  - This included baseline questionnaire variables for the summary scores of the three-factor eating questionnaire (TFEQ), food choice questionnaire (FCQ) and sweet questionnaire (SQ).
- Demographics lifestyle and knowledge **(All)**
  - All demographic variables: age, gender, ethnicity, occupation, education level, main cook in household, religious affect, income level, diet type, SF36 summary scores; PCS, MCS, GSLTPAQ, total knowledge of dietary recommendations, and sugar recommendations.
- Taste outcomes **(All)**
  - Supertaster status (gLMS categorised), sweet liker status (categorised), taste liking and intensity for both papers and liquids. Foods consumed of; High sugar (g), Medium sugar (g), Sweetener (g), High sugar (n), Medium sugar (n), Low sugar (n), No sugar (n), Sweetener (n), Total items (n).
- Additional lab variables **(Lab)**
  - Variables as outlined above in taste outcomes plus, Liking TLA, intensity TPB, liking TPB and baseline bodyfat percentage.

Correlations for whole study population

For the outcome percentage baseline free sugar intakes, SQ3, SF36 MCS, age, and Sweetener (g) variables were found to have significant associations in the whole study population. Total energy intakes at baseline were associated with TFEQ-UE, TFEQ-EE, FCQ6, FCQ7, FCQ9, SQ2, age, occupation, education, liking of taste paper A, High sugar (g), Medium sugar (g), Sweetener (g), High sugar (n), Medium sugar (n), Low sugar (n), No sugar (n) and Total items (n). Baseline bodyweight and waist circumference variables were both associated with TFEQ

UE, TFEQ EE, PC1, PC2, PC4, GSLTPAQ, SF36 PCS, gender, total knowledge and sweetener (g). The baseline waist circumference was additionally associated with FCQ3, FCQ4, FCQ7, age and occupation. All associations were significant to p<0.05 with the values shown in table 3.5 below. The associations from these baseline models were then included in a series of multiple regression analyses for endpoint outcomes and variables.

Table 3.5
Correlations for baseline main study variables in all participants

		Free sugar %	Bodyweight	Waist	Total energy
Model 1	Total energy		.167**	.157*	
	Bodyweight	-.163*£		.893**	.167**
	Waist		.893**		.157*
	D-Age	-.143*		.211**	.169**
	D-Gender		-.259**	-.280**	
Attitudes and behaviour	TFEQ – UE		-.274**	-.221**	-.239**
	TFEQ - EE		-.302**	-.269**	-.202**
	FCQ3			.158*	
	FCQ4			.131*	
	FCQ6				-.183**
	FCQ7			.144**	-.171**
	FCQ9				.140*
	PC1		-.203**	-.181**	
	PC2		.152*	.171**	.202**
	PC3	-.194**			
	PC4		-.165*	-.155*	
Demographics, life & knowledge	GSLTPAQ		-.139*	-.165*	
	SF36 PCS		-.315**	-.344**	
	SF36 MCS	-.192**			
	D-Occupation$		.135*	.139*	.265**
	D-Education lvl$				.156*
	K-total recc		-.181**	-.150*	
Taste	Liking TPA				.136*
	High sugar (g)	0.181**			0.212**
	Medium sugar (g)				0.130*
	Sweetener (g)		0.218**	0.189**	
	High sugar (n) $	0.297**			0.250**
	Medium sugar (n) $				0.227**
	Low sugar (n) $				0.286**
	No sugar (n) $				0.135
	Sweetener (n) $				0.201**
	Total items (n) $				0.338**

*= significant to p<0.05, **significant to p<0.001, $ = spearman correlations used, where $ is not denoted Pearson correlations are used. Three factor eating questionnaire (TFEQ), uncontrolled eating (UE), emotional eating (EE), food choice questionnaire (FCQ), sweet questionnaire components (PC), Godin-Shephard leisure time physical activity questionnaire (GSLTPAQ), short-form questionnaire (SF-36), physical component summary (PCS), mental component summary (MCS), taste paper A (TPA).

Correlations for lab subgroup

In addition to the variables above, baseline free sugar intake is significantly associated with liking for TLA and TPB. Baseline total energy intakes were also significantly associated with liking for TPB. Baseline bodyweight and waist circumference were not significantly associated to variables.

Table 3.6

Correlations for baseline variables in lab subgroup

		Free sugar %	Bodyweight	Waist	Total energy
Taste & BU variables	Liking TLA£	.185*			
	Intensity TPB£				-.176*
	Liking TPB£	-.161**			.208**
	Bodyfat %£		.513**	.530**	

*= significant to p<0.05, **significant to p<0.001, $ = spearman correlations used, where $ is not denoted Pearson correlations are used. £ = Correlations just on BU variables and lab participants. Taste liquid A (TLA), taste paper B (TPB).

3.5.2.1 Multiple regression two

Multiple regression models were repeated in the whole study population (N=242). Regression models used endpoint variables that were first checked for multicollinearity.

In the whole study group, the following endpoint variables were correlated >0.7

- FS2, High sugar (g) and High sugar (n)
- BW2, none
- WC2, none
- TE, High sugar (g), Medium sugar (g), Sweetener (n), High sugar (n), Medium sugar (n), Low sugar (n), No sugar (n) and Total items (n)

Results are reported as data analysed in all participants. Where analyses have been completed in the whole population, or intervention-only subgroups, the name of the analyses will be followed by subscript "All", or "IV", respectively. Where values exceeded 0.7 the regression model was repeated for that variable. In the results writeup, where additional variables did not add to the significance of regression models only the first regression models' values were reported as listed before 'OR' in the order of the variables below.

Where variables were correlated to >0.7 and repeated tests were found to be significant, the following classification was used to differentiate between tests. In tests for the whole group (e.g. $TE2_{All}$) this is classification and differentiation between tests is described using subscript numbers (e.g. $TE2_{All}$, Total items $(n)_1$; OR High sugar $(g)_2$ etc.

- FS2 - Endpoint free sugar intakes
    - $FS2_{All}$ Endpoint SQ3, endpoint SF36 MCS and endpoint; High sugar (g) OR High sugar (n).
- BW2 - Endpoint bodyweight
    - $BW2_{All}$ Occupation, endpoint; TFEQ-UE; TFEQ-EE; PC1; PC2; PC4; GSLTPAQ; SF36 PCS; total knowledge and sweetener (g).
- WC2 - Endpoint waist circumference
    - $WC2_{All}$ Occupation, endpoint; TFEQ-UE; TFEQ-EE; PC1; PC2; PC4; GSLTPAQ; SF36 PCS; total knowledge; FCQ3; FCQ4, FCQ7 and sweetener (g).
- TE2 - Endpoint total energy.
    - $TE2_{All}$ Occupation, education, liking TPA endpoint; TFEQ-UE; TFEQ-EE; PC2; FCQ6; FCQ7, FCQ9, and Total items $(n)_1$; OR High sugar $(g)_2$; Medium sugar $(g)_3$, Sweetener $(n)_4$; High sugar $(n)_5$, Medium sugar $(n)_6$, Low sugar $(n)_7$, No sugar $(n)_8$.

***$FS2_{All}$* -** Endpoint percentage free sugar intakes were not significantly predicted.

***$BW2_{All}$* -** Endpoint bodyweight was significantly predicted, $F(10,231)=6.368$, $p<0.001$, $R^2=0.22$, R^2 adj=0.18. Only the TFEQ-EE (b=-0.157, $p<0.001$), occupation (b=1, p=0.032) and SF36 PCS (b=-0.388, p=0.002) added significantly to the prediction $p<0.001$.

***$WC2_{All}$* -** Endpoint waist circumference was significantly predicted, $F(13,228)=5.435$, $p<0.001$, $R^2=0.24$, R2 adj=0.19. Only the TFEQ-EE (b=-0.096, p=0.015), SQ PC2 (b=4.488, p=0.026), SF36 PCS (b=-0.315, p=0.004), and FCQ4 (b=3.497, p=0.039) added significantly to the prediction $p<0.001$.

$TE2_{All(1)}$ Endpoint total energy was significantly predicted, $F(10,231)=2.267$, $R^2=0.10$, R2 adj=0.06, p=0.011. Only the endpoint TFEQ-EE (b=-3.745, p=0.029) and endpoint FCQ 9 (b=142.452, p=0.007) added significantly to the prediction $p<0.05$.

3.5.2.2. Multiple regression three

Taking the same variables used in analyses one and the significant predictors from regression two. These variables were combined into the following four models.

- FS3 - Endpoint free sugar intakes
    - Group, baseline FS%, baseline body weight, gender, age, endpoint; physical activity total energy.
- BW3 - Endpoint bodyweight
    - Group, baseline FS%, baseline bodyweight, gender, age, endpoint; physical activity; total energy; TFEQ-EE, SF36 PCS and occupation.
- WC3 - Endpoint waist circumference
    - Group, baseline FS%, baseline waist circumference, gender, age, endpoint; physical activity, total energy, TFEQ-EE, PC2, SF36 PCS, and FCQ4.
- TE3 - Endpoint total energy
    - Group, baseline FS%, baseline total energy, gender, age, endpoint, physical activity, body weight, TFEQ-EE, and FCQ 9.

Results are reported as data analysed in all participants.

$FS3_{All}$ - Model one for prediction of endpoint free sugar % intakes was unchanged due to no additional significant findings in model two.

***$BW3_{All}$* -** Endpoint bodyweight was significantly predicted $F(10,231)=865.25$, $p<0.001$, $R^2=0.97$, R^2 adj=0.97. Only the baseline body weight (b=0.944, $p<0.001$) added significantly to the prediction. In addition, the group (b=-0.366, p=0.053) and gender (b=-1.496, p=0.059) variables showed marginal significance.

***$WC3_{All}$* -** Endpoint waist circumference was significantly predicted $F(11,230)=128.24$, $p<0.001$, $R^2=0.86$, R2 adj=0.85. Only the baseline waist circumference (b=0.882, $p<0.01$) added significantly to the prediction $p<0.001$.

***$TE3_{All}$* -** Endpoint total energy was significantly predicted, $F(9,232)=8.09$, $R^2=0.24$, R2 adj=0.21, $p<0.001$. Only the baseline total energy (b=0.334, $p<0.001$) and endpoint TFEQ-EE (b=-2.138, p=0.047) added significantly to the prediction $p<0.001$.

3.5.2.3. Exploratory analysis

Adherence (summed)

At all five timepoints participants were given a score of either 1 (adherent) or 0 (non-adherent). These time points were then combined into a summative score, with higher numbers indicating more consistent adherence across the study. Correlations between total adherence endpoint, FS%, waist circumference, body weight and total energy were investigated. After Bonferroni corrections, a significantly moderate correlation was found between total adherence and endpoint FS%, r(237)=.-379, p<0.001. A linear regression found change in FS% was significantly predicted by summative adherence score *F* (2,240) = 189.26, p<0.001, R^2=0.44, R^2 adj =0.44, b=2.159 p<0.001.

Table 3.7
Adherence summed and FS% change.

	Adherence score					
	0	1	2	3	4	5
FS% Change	+4.04±4.19	+0.8±4.29	-0.46±5.11	-1.44±4.32	-3.17±4.45	-7.84±4.32
Baseline FS%	8.27±2.71	8.50±4.18	8.79±3.54	9.35±3.78	10.62±4.13	13.25±5.92
Endpoint FS%	12.31±4.04	9.30±4.96	8.33±6.15	7.92±4.48	7.44±4.10	5.41±3.53

Footnotes: Adherence was scored at each time point by either achieving ≤5% TEI of FS%, or ≥2% change in TEI of FS% from baseline. Scores across each time point were summarised into a single adherence score to represent adherence consistency across the study.

The above analyses were repeated to exclude timepoint 5 in the sum for adherence. There was no difference between the two analyses with the results included in Appendix 13.

<u>Anthropometrics change</u>

Correlations between total adherence and change in bodyweight and waist circumference were investigated. After Bonferroni corrections, there was a small positive correlation between total adherence, change in waist circumference r(239)=206,p=0.013 and change in body weight, r(239),=198, p=0.016. A linear regression between change in BW and adherence TP 5 was non-significant. A linear regression between change in WC and adherence sum TP5 was non-significant.

<u>Dietary profile</u>

Change in dietary intakes was calculated by subtracting the percentage at baseline with the percentage at endpoint. Correlations between changes in the percentage intakes of free sugars, carbohydrates, protein, fat and saturated fat were investigated. After Bonferroni corrections, only change in FS was significantly correlated with change in carbohydrates $r(237)=0.228$, $p<0.001$.

A paired samples t-test was run to compare baseline and endpoint means for percentage intakes of free sugars, carbohydrates, protein, fat and saturated fat. After Bonferroni corrections, only the free sugar percentage was significant $t(434)= 6.515$ $p<0.001$.

Godin-Shephard Leisure-time Physical Activity Questionnaire categorised.

A paired samples t-test between baseline and endpoint categorised GSLTPAQ was run in all participants, and also separated by group. Both tests reported no significant differences between baseline and endpoint GSLTPAQ categorised scores. This test was also run in the complete scores which replicated the non-significant findings. table 3.8 below outlines the even proportion of participants activity levels across the groups, with around half of participants likely to be achieving government activity levels, by being classified as active. Those categorised as insufficiently or moderately active were unlikely to be achieving physical activity recommendations.

Table 3.8
GSLTPAQ activity categorised at baseline and endpoint

	Baseline				Endpoint			
	C	N	NF	NFS	C	N	NF	NFS
Insufficiently active	15	19	15	17	17	17	17	13
Moderately active	18	17	16	14	13	13	13	18
Active	25	25	29	32	28	31	30	32

Footnotes: Categorised according to Godin 2011, ≥24 categorised as active, ≥14 -23 categorised as moderately active and <13 categorised as insufficiently active. Godin-Shephard Leisure Time Physical Activity Questionnaire (GSLTPAQ)

3.5.2.4. Summary finding: Two

- Model FS1 significantly predicted FS% at endpoint. FS2 and FS3 models did not add to these findings.
- In BW2, for all participants, endpoint bodyweight was significantly predicted by TFEQ-EE and SF36 PCS. After taking the significant contributors from BW1 and BW2 into model BW3, group and gender were marginally significant in prediction of endpoint bodyweight.
- In the regression models for prediction of endpoint waist circumference in all participants, model WC2 for reported that TFEQ-EE, SQ PC2, SF36 PCS and FCQ 4 all

significantly contributed. In WC3 for all participants, only the baseline waist circumference added significantly to the prediction.

- In the regression model for the prediction of total energy intakes at endpoint, TE2 model for all participants found TFEQ-EE and FCQ9 significantly contributed to the prediction. However, in TE3 only the baseline total energy and the TFEQ-EE significantly contributed.
- Summative adherence scores significantly predicted change in FS%. A small positive correlation between change in waist circumference and change in bodyweight with total summative adherence score was found.
- Change in free sugars was significantly correlated with change in carbohydrates. Only the dietary profile component free sugars differed significantly between baseline and endpoint, compared to carbohydrates, protein, fat and saturated fat which were non-significant.
- There was no significant difference between the baseline or endpoint for GSLTPAQ scores.

3.6. Analyses two – Secondary analyses.

Participant subgroup analyses for, gender, BMI, sweet liker status and super taster status were investigated, however these analyses were either non-significant or did not add to the findings in this section and therefore not included in this writeup. A report of the tests done, and the findings are included in the Appendix 13.

Complete Case Analysis (CCA) commentary

The above analyses have been repeated as a complete case analysis with full results in Appendix 14 Overall, the results of the CCA mirrored MI dataset analyses findings, with only a few differences. Any differences deemed more important are outlined briefly below. In $BW1_{All,}$ the CCA found that group, gender and age also significantly contributed to the model. In $BW3_{All,}$ the CCA found that group, gender, age and EP SF36 PCS added significantly to the prediction. When investigating anthropometrics change, the CCA regressions were significant. A linear regression between change in BW and adherence sum TP5 was significant $F(1,145)=5.16$, $R2=0.03$, $R2$ adj = 0.03, $b=0.277$, $p=0.025$. A linear regression between change in WC and adherence sum TP5 was significant $F(1,44)=6.66$, $R2=0.04$, $R2$ adj = 0.04, $b=0.581$, $p=0.011$.

4. Qualitative results

4.1. Participants

Interviews (solo n = 59 and pair n = 3) were conducted. Of the 59 solo interviews, 53 participants were female (F) and 6 were male (M). In the interviews conducted in pairs, participants resided in the same household, with two interviews being couples (1M, 1F)(1F, 1F) and the third being father and daughter (1M, 1F). Participants were recruited from the main reducing free sugars study if consent was given regarding the optional interview. The majority of participants were interviewed in 2021, with a final nine participants interviewed in the first quarter of 2022. Twenty-six participants were completing the study from home, and thirty-nine attended test days at Bournemouth University. All interviews were conducted remotely via zoom or telephone. Participant demographics in the interview subgroup was as follows. Ten participants were aged 18-29 years, eleven 30-39 years, twenty-four 40-49 years and twenty 50-65 years. In regard to BMI demographics, thirteen participants had a lean BMI of 18.5-24.9 kg/m2, twenty-nine were overweight (BMI of 25-29.9 kg/m2), and 13 were obese (BMI of >30 kg/m2).

Even interview allocation across weeks one, two, four, eight and twelve was completed to ensure all groups were represented at each timepoint (TP). The number of individuals interviewed in the control group was the lowest whereas the NFS was the highest. An average of 16 interviews was completed in each group, with 13 interviews at each TP.

Table 4.1: Interview frequency by group and interview week

	Control	N	NF	NFS
W: 1	2	1	4	2
W: 2	2	3	2	4
W: 4	3	1	4	5
W: 8	1	5	3	5
W: 12	3	4	3	8

Footnotes: Numbers shown are interview frequencies. Abbreviations used: Week (W), Nutrient group (N), Nutrient and food group (NF), Nutrient food and swaps group (NFS). Control group (n=11), Nutrient (n=14), NF (n=16) and NFS (n=24). W: 1 (n=9), W: 2 (n=11), W: 4 (n=13), W: 8 (n=14) and W: 12 (n=18)

As analyses will be completed across group, interview timepoint and adherence score, table 4.2 provides the detail of the amount individuals interviewed across each adherence score. It is recognised that there was a less individuals interviewed at adherence score 0 than adherence score 5, Zero (n=6), One (n=7), Two (n=12), Three (n=12), Four (n=9) and Five (n=19) respectively.

Table 4.2: Interview frequency by group and adherence score

Adherence score	Control	N	NF	NFS
Zero	2	2	0	2
One	3	1	1	2
Two	3	2	3	4
Three	0	3	2	7
Four	2	1	3	3
Five	1	5	7	6

Footnotes: Footnotes: Total numbers in each group shown in paratheses. Numbers shown are interview frequencies per summative adherence score. Abbreviations used: Nutrient group (N), Nutrient and food group (NF), Nutrient food and swaps group (NFS). Control (n=11), N (n=14), NF (n=16) and NFS (n=24), Zero (n=6), One (n=7), Two (n=12), Three (n=12), Four (n=9) and Five (n=19). Adherence was scored at each time point by either achieving ≤5% TEI of FS%, or ≥2% change in TEI of FS% from baseline

4.2. Barriers and facilitators to adherence

A total of seven themes and fourteen sub-themes for barriers and facilitators to adherence were identified. The seven main themes are described with the fourteen negative or positive subthemes for adherence included under each heading (figure 4.1). Themes and subthemes are presented and discussed in no particular order. Example quotes are followed with characteristics of the interviewed participants, this included and anonymised participant number (e.g., P1), the individual's group being control (CG), Nutrient (N), Nutrient and food (NF), Nutrient, food and swaps (NFS), individuals' gender as either male (M) or female (F), age in years and BMI category as lean, overweight or obese.

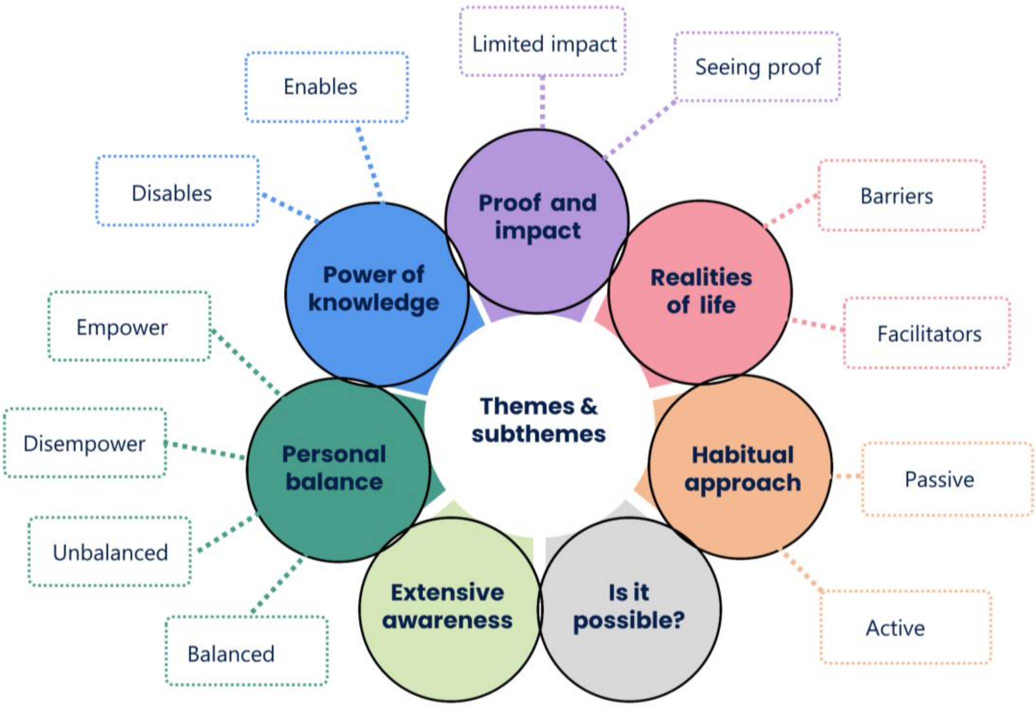

Figure 4.1: Themes and subthemes

4.2.1 Proof and impact

- Defined as the impact and perceived proof of recommendation adherence.

During interviews individuals commented on the changes they had, or had not, seen during their participation in the study trial. This theme appeared whether individuals were consciously or subconsciously looking for a sense of proof during their participation and attempts at adhering to dietary advice. This included both proof of changes that were beneficial for themselves, or their health, proof that there was no change at all, or proof that they already had a good diet and sufficient knowledge. This proof could come from both perceptions of perceived benefit, such as improvements to sleep, skin, energy levels and mental health. Comparatively not seeing proof, or progress, limited changes where positive change was anticipated therefore, presented as more of a barrier. This theme is split into the two sub themes of **'Seeing proof'** and **'Limited impact'**. Seeing proof included whether individuals had experienced any physical, mental and habitual changes and therefore proof of impact for their participation and efforts.

> *So I think you know, like the changes that I've made with the couple of food items that I've changed, I think that you know, that does make you feel better, um that you found something that actually fits with the way that you want to eat and you know is healthier, um, so that's a really nice change, um, and really positive from this study. (P57, NFS, F, aged 52 years, overweight BMI)*

Proof of the impact of dietary change could be both positive or negative, such as taste flavours now being too intense, adverse physical effects such as light-headedness or headaches, or individuals expressing that they now have more energy and feel less lethargic.

> *It's quite difficult, and I have found occasions where I've been quite lightheaded ((laughs)), because I've cut back so much. (P29, N, F, aged 51 years, overweight BMI)*

Limited impact regards individuals not seeing any changes and their participation having no impact on their life. This may have been no changes to their eating behaviours, views of dietary health, food choice, knowledge, with no perceived benefit from their participation and negativity to progress adherence.

Urm, no other than just finding it a hassle to follow the recommendations that I was given. Other than that, it hasn't made any change to my life. (P15, CG, F, aged 44 years, overweight BMI)

4.2.2. Realities of life

- Our individual or societal environment and daily habits can facilitate or limit adherence to recommendations.

Individuals described their personal and wider environmental factors and daily habits that did or could affect their adherence to dietary recommendations or achievement to a perceived healthier diet. This theme also includes comments regarding habit changes that impacted personal or wider environment and likely facilitated or limited adherence or healthier dietary practises. Also discussed were the aspects of the environment that need greater controls as currently these are or would be barriers or facilitators to adherence. This theme is subsequently split into the two sub themes of **'Life facilitators'** and **'Life barriers'**. For some having access to convenient good quality food was a facilitator whereas for others the proximity to unhealthy choices presents as a barrier.

I think … it's largely where people live, you know. If you live in more like Central London, or you around the states you've got lots of Kebab shops around and you're probably going to be more tempted to go and go there aren't you.(P4, N, M, aged 30 years, lean BMI)

Individuals expressed how living in a family was maybe more of a distraction from personal dietary goals, as you may be cooking for multiple people whereas living alone was described as having much more control in regard to dietary intakes in the home.

If I was living on my own I wouldn't probably have foods that I want to eat near me, if I was just trying to avoid them, but obviously when you share house with someone, ultimately you have to eat, not have to, but you're more tempted to eat what what they bring home. (P27, NF, F, aged 32 years, overweight BMI.)

The sub-theme **'life facilitators'** outlines instances individuals described as being helpful for dietary change.

I've hopefully got a bit more time, err, to do that urm, and a bit more motivation with some goals in mind. (P16, N, F, aged 27 years, overweight BMI).

I think the more people that get healthy, the, the, the people that aren't eating as healthy would probably end up looking and thinking, well, I want to be like, I'm not happy ((sighs)), so it would all become um an influence. (P12, NFS, M, aged 45 years, lean BMI).

The sub-theme '**life barriers'** outlines instances participants described as being unhelpful for adherence to dietary advice.

I do as, if like, renovation in my house kind of got in the way, and kind of, yeah, got in the way of anything like really getting on it and sticking with it. (P33, NFS, F, aged 28 years, obese BMI)

Umm, so well work got a bit busy….when I have the time it-it's a lot easier to do, and then when I'm busy I don't want to stand in a supermarket and compare, then come home and make everything from scratch. (P42, NF, F, aged 31 years, obese BMI)

Participants comments also alluded to the feeling that their environment was not conductive to adherence to this recommendation.

Urm, because society doesn't agree with what your recommendation was. So, so sort of going against what society is doing if that makes sense. (P31, N, M, aged 55 years, lean BMI)

4.2.3. Personal balance and empowerment

- Our attitudes, personality and thought processes can be positive or negative for adherence/nonadherence.

The theme 'personal balance and empowerment' includes an individual's personality traits. their attitudes and approach to food and diet. Our personal approach to the world, separate from the realities of life includes our attitudes, emotional responses and personality. This theme is subsequently split into the four sub themes of '**Balanced', 'Unbalanced','** **'Empower'** and **'Disempower'**. The subthemes balance and unbalanced, empower and disempower, contain inverse codes within each. This theme regards how we respond to challenges and change. Are we likely to be more positive, or negative? Have a balanced or unbalanced view of the world? For example ‘unbalanced’ legalistic thinking, or being too extreme towards eating may be beneficial for a time, but often not long term. Whereas having a ‘balanced’ view of dietary factors is described as eating in moderation across food groups and occasions.

> *So, it's kind of just, it's a balance, and it's it's about kind of, you know, not saying never to anything, because I think if you block out an entire food group, then actually that can cause more problems, so it's about balance and moderation and just being aware. (P106, NF, F, aged 40 years, obese BMI)*

Participants perceived themselves and others as either having free choice and responsibility to ‘empower’ their dietary intakes or not. The way we approach change personally as being our responsibility or not is a factor distinct and separate from our habitual approach. With those perceiving more responsibility and ‘empowerment’ more favourable for adherence, and those more influenced as with less personal choice unfavourable being ‘disempowered’.

> *But I think ultimately it is that individual’s freedom of choice, urm and their responsibility, urm, it's just that some people can be influenced more than others. (P9, CG, F, aged 34 years, lean BMI)*

Individuals described moments when others were apathetic to adherence which may ‘disempower’ dietary adherence. Whereas those taking more ownership, engaging with, and being interested in encouraging dietary adherence a position to ‘empower’. Individuals seemed to either take ownership of this or not, being empowering or disempowering for adherence respectively.

> *Whereas I think a lot more people find it easier to sort of fall off the waggon “oh, I'll just have this”, “oh I'll have that coz it won't really matter”, “it's just the one time”. I've got a lot of friends that say to me, “oh, you find it really easy to follow a diet”, but I don't, it's just some people obviously make more excuses than others. (P64, NF, F, aged 41 years, overweight BMI)*

> *If you're not willing, then it's not going to be, urm, it's not going to be something that*

you're interested in even engaging in. So, urm I think you have to have an, a willing party as well as the information readily available. (P5, N, F, aged 24 years, overweight BMI)

Traits such as emotionally regulated eating, impulsivity and general willpower are presented as factors that can empower or disempower adherence. The personality trait of having willpower is described as positive for adherence (empower), whereas the inverse, lacking willpower is described as having a negative effect on adherence (disempower).

Erm, like I guess willpower is a lot of it, in that if you don't have much will power than you're just going to give in easily if somebody offers you something, then you're gonna say yes nine times out of 10. (P33, NFS, F, aged 28 years, obese BMI)

4.2.4. Habitual approach

- Concerns practical habits for adherence to recommendations and changes made.

Individuals described the changes they had made OR not made regarding their eating behaviours and habits. Although an individual's personality, willpower and willingness discussed in the earlier theme will have an impact on the likelihood to undertake change, habitual approach separates this by describing not just likelihood of change but what changes the individual undertook. This theme contains the two sub-themes **'Active'** and **'Passive'** for the way individuals described their habitual changes. For example, has there been and active approach to change habits and therefore the individuals has described the habit change they have made, or are aware of a change that others could make that would be desirous for adherence. Active habits would include, being proactive in doing more research and expanding knowledge. In addition, an active habit could be described as approaching eating purposefully and deliberately seeking non-food-focused social activities.

Yeah, um I'm not constantly thinking about food, and I think about what I'm eating better, and I'm not snacking so much. Yeah, I'm not snacking so much. (P13, NF, F, aged 45 years, obese BMI)

I have lots more washing up because I'm cooking, I'm cooking food from scratch, rather than… necessarily grab and go food. (P1, NFS, F, aged 43 years, obese BMI)

I've been choosing fruit as a substitute for, instead of having a bar of chocolate. (P97, *N, F, aged 45 years, obese BMI)*

Alternatively, the individual has more of a passive approach and does not think they need to change anything, for example they already have knowledge, already have a good diet and perhaps need an external motivator or some sense of accountability to make a change.

> *Um I think I'm good on the days where you're asking us to record our food. ((both laugh)). So I think that, act-actually has been the most useful thing, is the message from you in the morning, or just knowing that actually we're going to, for the next I don't know five days or so, record everything that we eat, that keeps me on the straight and narrow. (P65, NFS, F, aged 50 years, obese BMI and P68, NFS, F, aged 41 years, obese BMI)*

4.2.5. Is it possible?

- Are the recommendations achievable and what aspects are positive or negative regarding the advice provided.

The theme '**is it possible?**', conveys the reported achievability of the dietary recommendations for both the individual and wider society. This is different to previous themes that refer to the aspects of life (Realities of life) or self (Personal balance/empowerment) that limit or encourage adherence. Is it possible?, refers specifically to the nature of the advice provided as well as its perceptions. Responses included what participants found easy or difficult in reference to aspects of the recommendation itself. This presented as a complex picture as some perceived the task as difficult for the general public but achievable for themselves, often over varying time frames. Comparatively the approach to the simplicity of the advice received and how achievable the dietary goal likely impacted the view on whether the recommendations were actually possible. Comments on the simple, and specific nature of the recommendation were positive. The fact of just having 'one line' or 'one area' to focus on was seen as favourable and less complicated compared to other diets which may require change across multiple areas of diet.

> *I liked the d-dietary recommendation um, because it was very simple. It-it wasn't complicated, I've been on lots of diets, and they can be very complicated, but it was very straightforward. Um, you know it was this, this is what you need to do, and…you*

could encapsulate it in one sentence really. (P29, N, F, aged 51 years, overweight BMI)

Reports of difficulties with the numerical nature of the recommendation were reported from multiple sources. Confusion was likely to arise on not understanding how much individual's had consumed of one nutrient vs other nutrients when looking at the whole diet. This was more challenging to individuals unless they wanted to dedicate significant time and effort into logging or had interest in learning about the composition of food and drink items. Understanding the recommendation provided is a key point for the achievement of dietary goals with some individuals reported needing clarification regarding the recommendation they received.

I think, yeah, just in terms of … numbers of percentage of like daily intake, it can be quite difficult to grasp unless you're really like focused and interested. (P69, NF, F, aged 35 years, overweight BMI)

I think just maybe clarifying, I wasn't entirely certain about what it was when I first received it. Urm, so maybe just clarify that, that was the recommendation, I suppose. (P9, CG, F, aged 34 years, lean BMI)

If the recommendation was clearly understood, the advice provided was viewed as good or informative. Where further advice was recommended by participants, it often included suggestions such as better labelling, food and swap recommendations.

No not really, I think it's self-explanatory. The leaflets are good and informative. I don't think, I think they're fine the way they are. (P97, N, F, aged 45 years, obese BMI)

The theme includes clarity and understanding of the task they had been set, whether people felt they were following the advice, and which factors they were exposed to personally and in the environment which impacted the goals achievability, such as food labels and knowledge being tools to enhance perceptions of achievability. However, viewing the task as too difficult or not understanding in at all, would limit adherence as it produced negative aspects to adherence. Surprise at the level of recommended intake as being restrictive may harm the perceived achievability of the recommendation, with some viewing it as too challenging to follow over a longer period of time.

> *No way, ((laughs)) like when I was discussing it so, with colleagues at work and even my partner, it like, we're all talking about it and couldn't believe actually if you were to follow it properly as a diet long term how it feels really restricting. (P42, NF, F, aged 31 years, obese BMI)*

4.2.6. Extensive awareness and viewpoint

- Broadened awareness of food, and the influences of the government, family and friends on intakes.

This theme describes participants reporting the impact of the study on their awareness over different food items, intakes and outside influences. This awareness stemmed from participating in the research study but certain preconceptions were likely present before participation. Changes to the general awareness, or thinking more, were highly reported by participants.

> *I think it's definitely helped us in terms of thinking a lot more. (P37, NFS, F, aged 18 years, overweight BMI and P36, NFS, M, aged 48 years, lean BMI)*

> *I guess, trying to look at practical ways to make that change or reduction. Urm so yeah, it's, it's been something that's been on the forefront of my mind. Whereas previously, I didn't think too much about sugar. I would have perhaps focused food choices or drink choices on fats er or carbohydrates, so it's been an interesting insight. (P98, N, F, aged 40 years, overweight BMI)*

As we are all unique individuals, the way we are each mindful of these influences in life is also unique. While some may perceive friends and family to have influence over themselves, others may not. There were reports of family members not following the same diet and tempting participants, in addition to the awareness of the wider temptation from family and friends in social settings and the influence they may have on the individual’s choice.

Erm, they can make it, or they can be, make it worse, if especially, if we're going for urm, an evening of having a few drinks and they're "go and have another drink" or have urm, a "let's have some-some food and snacks" and you end up saying "yes". They do influence that because you might go, actually "I don't want another one", but I'm going to because I'm with my family and friends.(P53, N, F, aged 42 years, overweight BMI)

Additionally, the influence of the broader government and industry has on us is largely out of our control, but others may not be aware of this influence at all. There were comments both praising government influence, such as their impact on food labelling, but also comments condemning their efforts and stating more needs to be done.

Oh, definitely, they should be promoting it. You know, if they think, you know, they already do kind of encourage better diets, but I think they could do much better with all the you know, the bad artificial drinks and rubbish food that's out there for kids. (P97, N, F, aged 45 years, obese BMI)

This increase in awareness is distinct from knowledge in that our awareness is shaped by our collection of facts from both the wider world we live in and our personal one. To know one dietary recommendation does not increase dietary awareness alone, but it does help shape our overall collective viewpoint. The ability to be aware of the personal and physical world in which we all live, separate from knowledge and knowing, enables us to therefore do something about it. For example, we are exposed to food adverts consistently in normal everyday life, however where some participants reported feeling they were more tempted after this advertisement, others stated that it had no affect at all. Moreover, reports of the potential impact of advertisement on children, from social medica, food adverts and celebrities were stated. A large portion of taking part in the study appeared to be a broader sense of awareness of dietary intakes and influences. Individuals reported increases in the awareness of different foods, nutrients, intakes, and as well as the influence of using dietary logging app on awareness.

Um, but I think um, just realising actually w-what content was in certain foods, or or not even foods, because I think we naturally probably made assumptions on on what *our challenge was around, what we should and shouldn't be doing, and then actually realised there was a lot, there was a lot more effected, er or a lot more foods had more impact. (P37, NFS, F, aged 18 years, overweight BMI and P36, NFS, M, aged 48 years, lean BMI)*

4.2.7. Power of Knowledge

- Clarity of knowledge and the power of understanding, with the limitations of its absence.

The theme 'power of knowledge' describes the effect of having, or not having knowledge has on adherence to recommendations. Where confusion and the absence of understanding may limit adherence, clarity of knowledge gained and trust in its utilization enhances adherence to recommendations. Of course, just because you have knowledge does not mean you will make a change. This is why factors such as the 'realities of life' and 'personal balance' are independent but interrelated. Understanding food labels and the 'power of knowledge' is different from the theme 'is it possible?' as it pertains to current knowledge and understanding rather than specifically understanding the specific recommendations provided in this study. The 'power of knowledge' differs from 'extensive awareness' as it describes what we know about, food, ourselves and dietary recommendations. It is the statements of facts individually rather than what the collective of how this knowledge contributes to awareness. This theme is subsequently split into the two sub themes of **'Enables'** and **'Disables'**. Factors that improve knowledge likely enable individuals to make informed choices and decisions. Participants reported enhanced understanding of what ingredients were within some of their favourite foods, contributing to their further and future selection of food items.

Knowledge, knowledge, knowledge, so some of my favourite foods, I understand why they were my favourite foods now, urm, and they shouldn't be my favourite foods. Urm, so it's knowledge, so I'm sure if I didn't have knowledge and someone gave me some of those favourite foods again, I might go "ooh this is nice" and be tempted again, but now that I know I definitely don't think I'll go back to most of them. (P31, N, M, aged 55 years, lean BMI)

Individuals expressed the idea that we all have free choice however, without knowledge and understanding it will always present as a limiting factor for true adherence or improvement to dietary change.

So urm, I think you have to have an, a willing party, as well as the information readily available. (P5, N, F, aged 24 years, overweight BMI)

This misunderstanding may be contributed to by the misinformation, confusion and often conflicting messages in the overabundance of information. It comes down to the ability of the individual to separate fact from fiction. Responses alluded to the potential deception from food companies, the bombardment of information and mixed messages.

Um, I think it's, it's not always easy when you're sort of bombarded with advice from you know all media types. (P57, NFS, F, aged 52 years, overweight BMI)

Er, there's such a mixed picture, I think, in the advertising of food and drink, we go from the extremes of you know the kind of fast food, takeaway, deliveroo, get your food quickly and all that stuff thrown, to then erm, I guess the vegan thing is really kicked off. (P98, N, F, aged 40 years, overweight BMI)

In order to tackle this issue of misinformation, individuals highlighted the need to start education of nutritional knowledge and practical cooking instruction earlier in life. The ideas expressed being that by educating the younger generation we can limit bad habits, dietary behaviours and their physical consequences earlier.

Let's get into understanding it's just, I think it should start from schooling right through…its food education, because nothing's really bad for you, if you eat it in moderation, eat it as you should eat it. (P22, N, M, aged 57 years, lean BMI)

Urm, I do think that maybe from a younger age, there should be more nutrition, education, and obese, obesity is massive on the rise and the effect it has on the NHS. So, it's just the mass, and that's just a massive conversation, isn't it for that urm, but I think education is key. (P48, CG, F, aged 49 years, overweight BMI)

Urm, but you know, the, I know they've done a lot of work in helping children to try and think about healthy choices. Urm, but even you know, even cooking skills that, *cooking skills are taught but it's that children are taught realistic everyday cooking, err and making you know, making those sort of things accessible really. (P1, NFS, F, aged 43 years, obese BMI)*

Where having knowledge likely aids adherence, not having knowledge limits it. Individuals expressed their current level of understanding including descriptions of the usefulness of the knowledge and tools they would look out for in the environment, in addition to not having any current or prior knowledge and disadvantaging themselves.

Well, you've got all the nutritional things on front of foods green, green parts are good for you, and the ones that aren't you probably shouldn't have huge amount of any red ones, it's probably like once a week sort of thing. (P4, N, M, aged 30 years, lean BMI)

Further to the concept of knowledge level, some individuals described instances of dietary knowledge which was incorrect. The confidence in incorrect knowledge would limit adherence to the dietary recommendations, in both the present and future.

4.3. Comparisons across group, interview timepoint and adherence

As outlined in chapter 2 of this thesis, interview transcripts were charted onto a matrix for all codes and participants. This data was then assessed by theme and subtheme to produce a summary of each participants responses. Due to the length of the transcribed content, the manual summary outlined by the researcher was completed to succinctly define the content. This then allowed the researcher to compare these summaries across group, interview timepoint and adherence scores, with this data included in the results below. The results from this comparison are outlined by theme/subtheme. Where similarities and differences were observed across all themes this has been stated at the beginning of each section. Where subthemes are spoken about but not specifically references in text the subtheme is included in parentheses at the end of the sentences e.g., (**balanced**).

4.3.1. Group comparison

Overall commentary across the control, N, NF and NFS groups got longer in the descriptions provided. For example, the NFS group tended to have contributed the most between groups. Contribution to the sub theme limited impact was the most uniform across all groups. Responses from the control group tended to cover similar topics as those of the intervention groups however, responses were more general and less personalised. It does appear that individuals in the control group were still aware of many of the same factors as the intervention groups.

Extensive awareness and viewpoint

In all groups there were descriptions of being more conscious of eating; both government and individuals were suggested to have responsibility for intakes in addition, to the industry adding unnecessary ingredients to foods. The intervention groups specifically provided more commentary around food labelling. In the control group, comments were more generalised whereas intervention group sentiments were communicated at a more personal level, especially in NF and NFS groups where responses regarded the impact of their experiences from factors such as industry and labelling.

Habitual approach

In the '**passive'** subtheme all groups discussed being accountable with some level of influence of researcher observation mentioned. Comments within the '**active'** subtheme focused on snack specific eating changes in all groups however, specifically the intervention groups talked about avoiding certain foods, or having made swaps or substitutions. The control group reported fewer specific changes and focused more on dietary planning, general healthy eating (e.g., drinking more water) and frequency of exercise. Comparatively the NFS group and other intervention groups suggested reduced versions of foods and more specificity in suggestions for snacks/other foods chosen.

Is it possible?

Overall, all groups commented that recommendations were considered achievable with dietary logging noted as being helpful in some way. Intervention groups mentioned specifically that having a knowledge of their baseline intakes would have been helpful for future changes as it would allow them to know how much they needed to change. Intervention groups mentioned more achievability difficulties such as the recommendations being more challenging longer term or at the very start of the intervention period.

Personal balance and empowerment

In the '**unbalanced**' subtheme, all groups referred to foods as 'naughty', 'treat' or having 'bad' days of eating. The intervention group included commentary on the use of artificial ingredients, specifying sweeteners with these items not preferred and sometimes avoided. In the inverse subtheme '**balanced**' all groups again reference the balance of eating different food groups however, NF and NFS groups spoke more about habit compensation and the balance of eating over days. The NFS group commented on the specific circumstances that substitutes may be used, and how eating is more personalised as your body craves things in moderation. In comparison the control group more often focussed comments on the balance between food intakes and exercise.

In the '**empower**' subtheme, all groups identified motivations for self, family or health. A strong theme throughout, was that individuals have free choice with strong willpower required to resist cravings. Additionally, those in the NF and NFS groups described themselves as 'all or nothing' types with being motivated for changes. For the '**disempower**' subtheme all groups recognised that some people are more influenced than others, with the strength of certain personalities being an influence. Some people described not being able to make changes due to willpower, self-discipline or just not being motivated to make the change (**disempower**). In the intervention groups, empowerment could come from making a specific food choice from a knowledge base, with positive emotions resulting from these subjectively 'better' choices (**empower**). Alongside this, intervention groups could have been disempowered with comments on negative emotions resulting from eating foods they knew the shouldn't. The NF and NFS groups spoke about social situations with references to eating with others and not wanting to pressure other individuals with dietary preferences.

Power of knowledge

As part of the '**enables**' subtheme all groups noted the importance of nutritional education. Education was commented on as especially important from a young age, with some suggestion that more could be done by the government for this. Intervention groups provided substantial commentary on nutritional labelling e.g., traffic lights. The NF and NFS groups spoke about the need for clarification of foods high in sugar, with the NF groups also citing some clarification on understanding sweeteners and foods substitutes required.

For the inverse subtheme '**disables**', all groups considered that some items such as multi-pack or bakery goods have poor labelling, with industry deception leading to them hiding ingredients. The intervention groups regarded some foods as being advertised as healthier than they are, with specific challenges in terms of eating out when trying to follow guidelines. The NFS group regarded how some information sources can present as conflicting advice, whereas the control and nutrient groups described the lack of information as being more of the challenge.

Proof and impact

Participants across all groups considering the app useful for seeing an overview of the diet. Individuals in the intervention groups provided additional commentary for the utilisation of logging for making food decisions. Furthermore, participants in the intervention groups commented on the changes to the taste of foods with flavours being more intense to items they had chosen to reduce or remove. In the control group, there was low contribution to the sub theme '**seeing proof**' whereas the NF and NFS groups provided commentary on physical changes such as improved energy, weight loss and general wellness. Within the sub theme '**limited impact'**, comments were generally uniform across the groups. The only difference being that intervention groups were often more detailed regarding food. For example, in the NFS group individuals would say the food is not dissimilar to what they like, whereas in the control group individuals would describe always enjoying food and always being a foodie.

Realities of life

In the identification of '**barriers**' participants in all groups acknowledge that eating away from the home and travelling is a limitation to healthy habits due to the difficulties in finding healthier choices or alternatives (**barriers**). Although we have food labels the impact of the food industry and the drive on sugar/sweets is acknowledged as not beneficial for change. Time management, busy lifestyle, and individuals perhaps not having the knowledge are factors described as barriers to change (**barriers**). Junk food was perceived as being cheaper, with healthy food described as often being more expensive or less accessible. Comments from the intervention groups regarded other people's eating habits within the household and them not adapting to your changes as being a barrier. Participants in NF and NFS groups both spoke about negative emotions from having to reject foods from family and friends, with that being something that was difficult (**barrier**). Intervention groups appeared to have more commentary than the control on the advertisement of certain foods, and how this is often pushed choices towards unhealthy and convenience foods.

Comparatively all groups considered ‘**facilitators**’ such as planning as being helpful for better food choices. If healthier food was cheaper and junk food was more inaccessible this would be a facilitator. It was suggested that friends and family that have a good outlook, or are supportive, can influence you to make better decisions (**facilitators**). In the intervention groups the process of making gradual changes or taking one day at a time was suggested as a facilitator. Further commentary in the intervention groups considered that physical distance from certain foods may be beneficial. Living on your own was also mentioned to be more helpful as you're more able to control the foods that you consume or buy. NF and NFS groups contained the most descriptive responses, but also some reference to the personal facilitators such as eating in moderation and being able to control your own intakes and portion sizes.

4.3.2. Interview timepoint comparison

Extensive awareness and viewpoint

Individuals across all timepoints commented on the government’s responsibility to education; by ensuring knowledge is accessible to all and that food standards and messaging aligns with legislation. In interviews at latter timepoints there was more focus on labels and nutritional information, with those at week twelve more concerned with the awareness of what changes they had made. In earlier timepoints there was references to thinking about the changes that may happen, whereas weeks two, four and eight talk about the awareness that they have from things like logging and realising what they ‘do’ eat.

Habitual approach

In the subtheme ‘**passive**’ all interview timepoints refer to being incentivised to make changes from the impact of being watched or taking part in the study. Week eight responses describe more instances of having been set in their ways, with habits being harder to change than any of the other weeks. At week twelve one participant said that they were more aware of the research or observation in the beginning but cared less as time went on.

In regard to ‘**active**’ changes all interview timepoints discuss the importance of planning ahead to some degree. At earlier weeks, individuals refer to changes back to fresh cooking, or an intention of what they are going to be doing. Whereas later weeks describe the changes that have been made or sticking with them. From week two onwards, there are descriptions of introducing variety into the diet, with foods such as fruit and veg specifically increased and chosen.

Is it possible?

Similar to the results reported in the group comparison, all interview timepoints generally describe the recommendations as achievable. At weeks one and two, there were greater comments on individuals referring to 'trying' to achieve the recommendations with the sentiments towards the interventions mostly positive. From week eight onwards there was some fatigue of dietary logging, with some uncertainty regarding if the changes they have made are correct. In addition, latter weeks include commentary on the critique of the information provided, regarding what additional information would be helpful.

Personal balance and empowerment

In the '**unbalanced**' and '**balanced**' subthemes, interviews at all timepoints described foods as being 'naughty' with the discussion of the balance of foods and eating throughout the day commented on respectively. In weeks eight and twelve from the '**unbalanced**' sub theme there was more talk about the changes in treats style rather than just referring to something as a treat. Comments across all interview timepoints also include not choosing foods because they are artificial and avoidance of these (e.g., sweeteners). For the '**balanced**' subtheme earlier interviews refer to healthier choices they can make and looking at ingredients when thinking about the balance of their diet. Whereas weeks four, eight and twelve include these comments, but also an awareness of the body through the craving of foods in the individualization and personalization of diet.

Similar to the group results, all interview timepoints recognised personal responsibility and willpower for eating, however in later interview weeks, discussions become more enlightened around food packaging and what they had learnt. In earlier interview weeks for the '**empower**' subtheme, comments regard individuals having an interest in nutrition with general comments about becoming more informed and interested in health. While this commentary continues to later weeks, there is more of a focus on the consistency and the emotional impacts of this from week two, such as feeling less guilty around 'bad' eating times. The inverse of this in the subtheme '**disempower**', interviews from week four onwards describe how individuals can influence others to make choices on their intakes, but also the fact that others are not always interested in making changes.

Power of knowledge

Looking across all timepoints commentary include some individuals regarded themselves to already have good knowledge, with labelling described as deceptive by the food industry. From week two interviews, education was regarding as particularly important from an early age, with reference to individuals having expanded their knowledge in the identification of foods. Week twelve interviews were particularly descriptive regarding individuals making more informed choices and knowing where to find information (**enables**). In interviews conducted at earlier timepoints, two participants mentioned not initially understanding the recommendation they were given, or first thinking they did but then realising they didn't. Separate to this, interviews from weeks eight to twelve particularly described food labelling as being poor with criticisms of the nutritional information portion sizes, traffic labels and jargon on ingredients lists (**disables**).

Proof and impact

Individuals across all timepoints included some commentary regarding the subtheme '**seeing proof**'. Comments include dietary logging being helpful for seeing an overview of what is being consumed, with physical and taste changes included from the very first interview week. Within this subtheme, interviews from week four provided frequent comments on increases in energy levels and physical changes such as improved skin and weight loss. In the sub theme '**limited impact**' there was generally the same comments across the interview timepoints with no specific changes in the commentary observed.

Realities of life

In the reporting of barriers, all timepoints regarded the same subject matter with no discernible trends or changes. This included unhealthy foods often described as being cheaper; healthier foods as more expensive; time; planning; job; personal stress; as well as eating out or socialising with friends being described as key barriers. Similarly, in the '**facilitators**' subtheme all interview timepoints highlighted the importance of cutting back or reducing the portion sizes, but not necessarily cutting them out completely. At latter timepoint interviews there was descriptions of friends and family being facilitators when having similar outlooks for foods, but this was described with a lesser focus on how other people can facilitate changes, whereas the earlier weeks focused on this more.

4.3.3. Adherence comparison

In general, across themes and sub themes it was challenging to see any differences across individuals' responses across the summative adherence (SA) score analysis. Individuals in SA score zero had the lowest contribution to quotes with those in the SA five having the longest responses.

Extensive awareness and viewpoint

Across the extensive awareness theme there was no directly observable differences between participants with different SA scores. Individuals across all SA scores felt awareness was important and tended to come from things like food labelling; expansion of knowledge; impact of dietary logging; or just generally from being aware of what you are putting in your body. It was generally thought to be a good idea that the government should be accountable for certain aspects of diet such as recommendation regulation, responsibility around guidance and packaging.

Habitual approach

In the '**passive**' sub theme there were again limited differences in reporting from individuals with differing SA scores. All interviews commented on the effect of being better on log days by making them more accountable for intakes. For the inverse sub theme '**active**' individuals with all SA scores spoke about reducing certain types of foods with specific reference to snacks. Commentary also included references to planning more in the preparation of meals/ food shopping. Comparatively those with SA scores of three and above provided additional comments regarding changes such as getting back to the exercise they were doing, going to the gym now, or expanding their knowledge more. Foods were specified in latter adherence score interviews with reference to alternatives used and swaps made.

Is it possible?

Across individuals in all SA scores the recommendations was generally thought of as achievable. Food labelling was generally perceived of as positive, with things like the traffic light labelling providing more of a visual and preferable opportunity to identify foods. However, there was an acknowledgement that better labelling of certain foods needs to be undertaken to help recommendations be even more achievable. Participants with lower SA scores had some confusion over the recommendation, regarding its boundaries and needing clarification. On the majority, across all the summative adherence scores the provided information was generally thought of as clear and concise. In those with higher SA scores there appeared greater confidence in if individuals were following the advice, whereas in individuals with lower SA scores descriptions were focused more on ‘trying’ to adhere to it and/or achieve it more.

Personal balance and empowerment

In the ‘**unbalanced**’ and ‘**balanced**’ subthemes reporting was similar across individuals with all types of SA scores. All SA interview groups describe foods as being naughty, bad, good, healthy or unhealthy (**unbalanced**). There was also discussions around being mindful of the foods that they were eating, with a balanced diet preferred (**balanced**). In reports for individuals in the SA group five, there were comments describing how for some individuals you'll never convinced them to change (**unbalanced**), this group also provided a more incorporated commentary between things like energy intakes, balance and lifestyle (**balanced**).

In the sub theme ‘**empower**’ individuals across all SA scores commented on the motivation for change coming from health issues, age, family, the self, knowledge of the links between diet and health, and the beneficial effects seen from initial changes of diet. Personality traits that were described as being empowering were being stubborn or strong, and having the willpower to change. Comparatively for the ‘**disempower**’ sub theme, there were responses that other people will do what they want to do, eating what they want whether that's good or bad. Looking back to the ‘**empower**’ subtheme differences, those with SA scores of two or greater provided commentary regarding the relationship between the physical effects and dietary decisions. For example, individuals from SA five outlined understanding the benefit and risk to these dietary changes. Moreover, reports from those with SA scores of five also referred to the enjoyment of the food they're picking and the changes they're seeing being empowering in a way to continue what they were doing. In the subtheme ‘**disempower**’, there was some discrepancy in reporting between those of lower and higher SA across. In reports from those with higher SA scores there tended to be discussions around the fact that health conditions may get in the way, with factors such as the impact of emotional eating discussed. In people with lower SA scores there was more reference to it not being all up to the individual to make changes, with some comments regarding the government and individuals being rebellious to the nanny state causing people to perhaps reject recommendations.

Power of knowledge

Across both the subthemes of '**enables**' and '**disables**' responses were similar. For example, in '**enables**' individuals across all SA groups considered education should be better especially for younger children. In addition, the reading of labels reportedly increased knowledge, that included ingredient list jargon, traffic lights, where to find this information, and how this information enables more conscious choice. For the inverse subtheme '**disables**' all individuals across all SA scores commented that misinformation was generally considered a factor, with criticism of the industry for being intentionally deceptive of what's in foods, labelling being poor, with certain foods not labelled at all making it hard to judge what you are consuming. In individuals with higher SA scores above three, there tended to be commentary on food specifics such as; clarification on not understanding what's best for us; whether information is disingenuous; and whether information from the government is actually what's right for us or just what they thought was achievable.

Proof and impact

In the subtheme '**limited impact**', the only observable difference between people with different SA scores was in the length or responses. For this subtheme people in all SA scores include some comments on limited change, no impact on knowledge, with some already thinking they had healthy habits. For the inverse subtheme '**seeing proof**' individuals in all SA scores described taste change descriptions with individuals enjoying certain foods they had reduced more, or less, with the change to these specific foods being now more pleasurable, e.g., fresh fruit and savoury foods. The negative physical effects from withdrawing from sugar was recognised across nearly all adherence scores. In individuals with summative adherence scores of two or more physical changes such as having more energy, clearer skin and weight loss were more commonly mentioned.

Realities of life

In the identification of '**barriers**' to following recommendations individuals across all SA scores reported similar factors such; as living as part of a family unit; price access; going out to eat; socialisin;g or attending specific social events. Comparatively similar reporting was found in 'f**acilitators**' with factors such as if healthy food was cheaper; junk food was more expensive; having access to good foods; with limited proximity to bad all described as helpful for following recommendations. Individuals with SA scores of two and above- described barriers such as the influence of food advertising and how the industry could be misleading and deceptive making this more of a barrier.

4.3.4. Researcher reflection four

The qualitative work with participants allowed for deeper understanding of this research but was also an opportunity for me to grow as a researcher. While the process of undertaking qualitative research can first appear simple, it requires more dedication and care than is first apparent. Having come from a quantitative background, the re-reading of transcripts, constant reviewing, and repetition of this over more than 50 interviews was mentally demanding and not something I fully appreciated until I had completed the work. Hearing from my participants during both interviews and at test days was a highlight to my work. It was astounding how much time these individuals donated to this research and something I will forever be grateful for. Listening to their experiences during the course of this research motivated me to continue when demands sometimes felt overwhelming.

I am reminded of one participant who described struggling to change their diet for years but on their participation in this research they were able to make changes they had scarcely attempted before. They described it as life changing, being the springboard to healthier lifestyle habits and the loss of over 10kg in weight. On that day, I could see the direct impact of my work and it made it all worth it. To know that even just one person could gain so much from this work meant the world.

5. Main discussion

This study investigated the effectiveness of three types of free sugar reducing advice on free sugars intakes in adults consuming >5% total energy intakes of free sugars. In addition to investigations into free sugar reduction, we sought to understand adherence to recommendations, as well as the associations of demographic, behavioural, lifestyle and taste factors on dietary change. Further qualitative work was completed to provide commentary on participants experiences within the study with the focus on identifying barriers and facilitators to intervention success.

Findings will be discussed in the order of objectives outlined in chapter 1 with the objectives included at the start of each section. Objective one addresses findings of free sugar intakes and adherence. Secondary and tertiary objectives regarding findings from anthropometrics, energy intakes, attitudes, behaviour, and taste status will then be discussed. The qualitative results addressing tertiary objectives will provide an overview of the themes identified, with commentary added for analyses undertaken for different intervention groups; interview timepoints and adherence (Boxall et al., 2022). Finally, limitations, future research, and study contribution will be discussed before concluding in a summary of the findings from this thesis (figure 5.1).

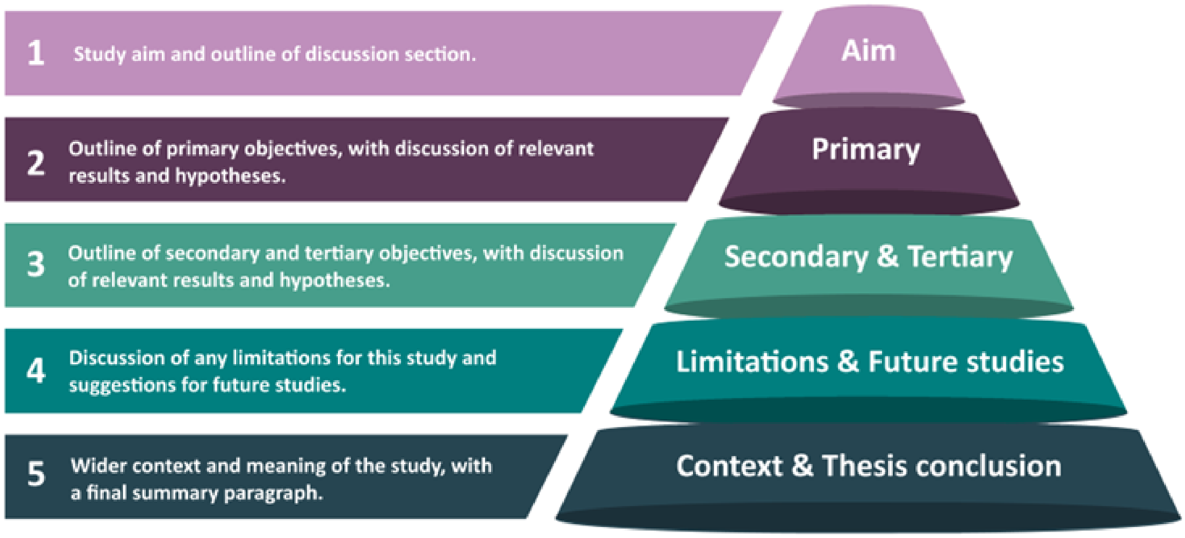

Figure 5.1: Outline of discussion thesis chapter

5.1. Primary objectives

- 1.1: To assess the effectiveness of nutrient, food and swaps-based recommendations to reduce free sugar intakes on percent of total energy intakes of free sugars from baseline to endpoint.
- 1.2: To assess adherence vs nonadherence rates to the dietary recommendations and drop off across the dietary assessment period and group.

5.1.1. Free sugar intakes

Overall, the primary analyses using multiple regression significantly predicted endpoint FS% at week 12 from group, baseline FS% and baseline bodyweight (FS1 model). Further to this, all-intervention groups, but not the control group, showed significant differences from baseline to endpoint FS%, with a reduction in intakes found. Baseline intakes for FS% for participants enrolled (10.3%) were comparable to national levels (9.9%), however at 12 weeks and after observed reductions in FS% no intervention group had achieved the <5% recommendation, with intakes of 7.1-7.7% FS% across the three intervention groups (Public health England, 2020a). This finding is encouraging in that it shows national dietary recommendations are effective at aiding the reduction of free sugars however, more needs to be done to reach the targeted <5% FS% intakes optimal for health (Public health England, 2020a). These findings of habitual change at 3 months are supported by comparable studies (Judah et al., 2020; Lamport et al., 2022). In Judah's study utilising reduction of SSB, reductions in SSB intakes were still significant at 2 months (Judah et al., 2020). Additionally earlier findings investigating advice from the Change4life campaign on reducing sugar intakes observed habitual changes and sugar reduction were still retained at 1 year (Lamport et al., 2022). Despite recommendations in this study being sufficient to reduce free sugar intakes, and other evidence supporting reductions in sugar (Lamport et al., 2022), and SSB intakes (Judah et al., 2020), the answer to the question of if advice alone is feasible to reach <5 FS% intakes is likely no. The UK Sugar Reduction Programme showed initial success with reductions of FS% from 11.8% in 2008 to 9.9% in 2019 (Public health England, 2020a). This research study found a further ~2% reduction in FS% with a targeted sugar reduction intervention delivered at a single timepoint however, this same effect was achieved over 12 weeks rather than the multiple years and campaigns of the Sugar Reduction Programme (Public health England, 2020a). Reports by Action on Sugar, (2022), and the findings from this study support a recommendation of greater legislative action and impact from government and industry for reducing intakes of free sugar.

When comparing recommendation type, there were no significant differences between intervention groups at baseline or endpoint, with the study powered for changes of >2%. It is perhaps unsurprising there were no significant differences between groups, as from reported interviews individuals may have completed their own research to reduce intakes rather than just relying on the information provided. This included advice such as food items, recipes, books and swaps as being beneficial for the achievability of the recommendations. Where advice was intentionally lacking, such as in the nutrient group, commentary regarding the improvement of advice was for further information of food items and suggested swaps. It could also be suggested that the advice provided was too similar between the intervention groups and not personalised enough to enact a substantial effect. Although individuals were screened to ensure intakes were above 5% TEI of FS, and randomisation used to control for uniformity in mean intakes across trial arms. There could have been some impact of individuals having only small adjustments to make e.g., <2% in their intakes which would minimise the statistical level of changes that could be observed. If this study was repeated it would be useful to initially include only individuals with higher intakes >10% to first identify how effective the recommendations are. This information could then be tailored and personalised in secondary research to potentially formulate more efficacious recommendations for both specific individual subgroups and free sugar intakes.

Furthermore, in taking part in the study and making dietary changes, some individuals commented on being motivated to make further changes in diet and exercise separate to the intervention. ***The hypothesis (H1) of 'Recommendation type is associated with reduction in FS% at 12 weeks' is partially accepted on the basis of intervention vs control did reduce FS% intakes however, there was no difference between intervention groups.***

5.1.2. Adherence

The main findings from adherence categorisation using adherent vs non adherent counts and a Chi-square test found a moderately strong association between group and adherence at timepoint one only. The adjusted residuals show the control group had lower reported adherence than the other groups. This result was perhaps to be expected considering adherence was based on the ability to reduce FS% intakes, with this group not given this goal and just instructed to log their dietary intakes. In general, the number of individuals categorised as 'adherent' reduced across timepoints 2-5, potentially contributing to the fact no significant associations were now found between the groups at these timepoints. Only those categorised as the most adherent across the study period (summative adherence 5) got the closest to the recommended <5 FS% intakes at 5.41% FS%.

In further exploratory analyses, change in FS% was predicted by summative adherence score, in addition to small positive correlations between total adherence and change in waist circumference and bodyweight. These finding support earlier suggestions that to enact long term change in diet and its physical outcomes, dietary changes should be sustainable (Hill, 2009; Hills et al., 2013; Lutes et al., 2008). Other evidence into diet tracking and weight loss across a 1-year period observed that frequent and consistent tracking (>228/343 days) had a significant impact on weight loss over time compared to those who were less consistent at tracking (114-228 days) (Ingels et al., 2017).

Despite this even the most adherent group (summative adherence 5) average intakes did not achieve the <5% intakes recommended. This is disappointing for long term national goals but perhaps unsurprising considering for a UK adult consuming 2000-2500 kcal a day, free sugar intakes would need to be less than 125 kcals, or 30g of free sugar a day (British Nutrition Foundation, 2021). Comparing this to visually healthy fruit snacks such as 'Tescos Apple & Sultana Bars' of which one 30g bar contains 4.6 teaspoons of sugar (18.4g), the scale of the challenge is evident (Action on Sugar, 2020). Furthermore, observations of adherence to national dietary guidelines across the globe have been shown to be generally poor (Batis et al., 2012; Kebbe et al., 2021; Leme et al., 2021; Scheelbeek et al., 2020; Yau et al., 2019b) especially in the case of sugar with only 24.2% of the UK population meeting UK targets (Scheelbeek et al., 2020). These findings of poor adherence to dietary guidance are not surprising, with reports by the World Health Organisation in 2003 outlining the need for multidisciplinary and tailored intervention approaches to combat these problems (World Health Organization, 2003). Despite more tailored interventions (Quintana-Navarro et al., 2020) there may always be risk of regression to previous habits (Downer et al., 2016).

To help limit regression to previous habit and enhance adherence, I would suggest that interventions for dietary changes need to be multi-factorial. Firstly, recommendations need to be tailored to an individual's lifestyle, circumstances, genetics, and intakes (Briazu et al., 2024; Shyam et al., 2022; Singar et al., 2024). By utilising genetic personalised nutrition, the dietary guidelines provided may optimise individual health outcomes. We can also use information related to our biological responses to certain foods to further understand what each individual may need (Shyam et al., 2022; Singar et al., 2024). Moreover, further than just our biology, tailoring interventions to socio-demographic, cognitive characteristics and sensory preferences has been shown produce advice that results in individuals being more likely to change their diet than if provided with generic government advice (Briazu et al., 2024). Secondly community programmes need to be employed and available to facilitate changes when individuals are motivated to do so (Moore et al., 2018). Government should review recommendations and their utility within the context of their use. Thirdly, more needs to be done at a national level regarding the society we live in. Changes could include; re-evaluating advertisement laws for foods items and limiting industry deception; updating dietary recommendations now and on a regular basis to reflect our community; bringing in stricter food labelling legislation to align recommendations to packaging information; introducing greater nutritional education from a younger age and incentivising or penalising industry for dietary formulations in similar approaches to the sugar tax (Action on Sugar, 2022). It is recognised that although dietary recommendations have direct importance, their utility is likely to be enhanced with a greater adherence to guidelines within a society that supports the foundations they are based upon. Individuals should not be left to struggle alone; with the support for change freely available.

The hypothesis (H2) of 'recommendation type will be associated with adherence' is partially accepted on the basis of intervention vs control did show variability in adherence however, there was no significant differences between intervention groups.

5.2. Secondary objectives

- 2.1: To explore associations between nutrient, food and swap interventions within subgroups of the study population, including gender and BMI.

- 2.2: To explore associations between nutrient, food and swap interventions with attitudes and behaviours, demographic and lifestyle variables, tastes outcomes and food outcomes.
- 2.3: To explore change in free sugar intakes and changes in dietary profiles including carbohydrates, protein, fat and saturated fat.
- 2.4: To explore associations between taster status, sweet attitudes, and total sugar intakes.

5.2.1. Bodyweight and waist circumference

The average BMI of participants was 27.72±5.73 kg/m2, with even proportions of lean, overweight, and obese BMI individuals 35.1, 35.1 and 29.8% respectively. This is comparable to UK adults' data from the Healthy Survey for England 2021, where the reported average BMI was 27.5 kg/m2, with 37.9% individuals overweight and 25.9% obese (NHS Digital, 2022). Recommendation group had a marginal impact on bodyweight at 12 weeks (BW1) with findings in the CCA significant. The mean endpoint body weight reduced in all intervention groups N, NF, and NFS by 0.72kg, 1.44kg, and 1.11kg, respectively, compared to no change in the control group -0.17kg. Mean endpoint waist circumference reduced in line with weight reductions in all groups N, NF, NFS, and control by 1.3cm, 2.8cm, 1.85cm and 0.44cm, respectively.

Out of nutrient, food and swap studies outlined in the literature review, three systematic reviews did not include bodyweight reports (Cecchini & Warin, 2016; Scapin et al., 2021; Shangguan et al., 2019), seven did not report complete anthropometric baseline and endpoint measures (Forwood et al., 2015; Judah et al., 2020; Lamport et al., 2022; Mason et al., 2021; Ni Mhurchu et al., 2018; Piernas et al., 2013; Woo Baidal et al., 2021), two used self-reported measures (Borgmeier & Westenhoefer, 2009; Koutoukidis et al., 2019), one utilised a population sample with much higher average obese BMI's >35kg/m2 (Tate et al., 2012), and one reported bodyweight changes during adolescent years so was not considered comparable (Ebbeling et al., 2012). In a female only overweight population, Lapointe et al. (2009) found those who received restrictive messaging lost weight significantly from baseline to 3 months -1.5kg±1.8kg (LOFAT group. At 6 months both participants in restrictive (LOFAT) and non-restrictive (HIFV) messaging groups significantly reduced bodyweight and waist circumference (Lapointe et al., 2009). A systematic review with meta-analyses on the effect of product reformulation on sugar intakes and health reported pooled RCT findings for bodyweight reductions of -1.04kg (Hashem et al., 2019) from three studies (Gatenby et al., 1997; Markey et al., 2016; Raben et al., 2002). The pooled RCT findings above (Hashem et al., 2019) utilising a similar 12-week time frame and intervention with restricted messaging found comparable weight loss as reported in the results from this study, with bodyweight reductions between 0.72-1.44kg. This evidence from literature supports the validity of this study's findings in the context of timeframe, intervention message and nutrient group targeted.

Changes in bodyweight are not just attributable to dietary intakes but also physical activity (Swift et al., 2014). Although recent debates on whether physical exercise causes meaningful weight loss have been discussed, it can be agreed that physical activity levels can impact weight even if the primary mechanism for weight change is diet (Robinson & Stensel, 2022). Using a paired samples t-test this study found no significant differences in GSLTPAQ categorised scores from baseline to endpoint. In two systematic reviews (Tcymbal et al., 2024; Van Poppel et al., 2010) into the utilisation of physical activity questionnaires it was found that no specific questionnaire was superior in validity, with the majority being of acceptable (Van Poppel et al., 2010) or weak quality (Tcymbal et al., 2024). The GSLTPAQ was not included in the later systematic review (Tcymbal et al., 2024), however the earlier study by Van Poppel et al 2010, reported that of the 23/85 questionnaires assessed as appropriate for a measure of physical activity, the Godin questionnaire had sufficient content validity (Van Poppel et al., 2010). As mentioned in the methods section of this thesis, the GSLTPAQ questionnaire is validated for use in the categorisation of individuals into the activity level categorisation. It was included to provide control for vast differences within groups for the reporting of physical activity. It is acknowledged that this questionnaire is likely not sensitive enough to account for individual variations in exercise, exercise duration or non-leisure time activities such as commuting to work. In this study's group-based interventions the GSTLPAQ can likely detect large changes in physical activity with low burden however, the subtle differences are unlikely to be accounted for (Ndahimana & Kim, 2017; Steultjens et al., 2022). In the measurement of physical activity in daily life, there can three broad methods for consideration, 1) self-reported questionnaires and diaries, 2) doubly labelled water (DLW), and 3) measures utilising body trackers. Of these three methods, utilising the measurement of DLW is the gold standard (Steultjens et al., 2022). This method can objectively measure chemical components in blood, saliva or urine over prolonged periods to accurately measure total energy expenditure. Although DLW cannot categorise energy expenditure across patterns of sedentary behaviour and light physical activity, it is minimally invasive as does not interfere with daily life (Ndahimana & Kim, 2017; Steultjens et al., 2022). In any future research it would be suggested that utilising the methodology of doubly labelled water in addition to body trackers would likely be the most minimally invasive and informative, although it is acknowledged this would likely come at a high resource cost.

5.2.2. Energy intakes and dietary profile

In addition to reductions in free sugars all groups including the control reported significant reductions in total energy intakes from baseline to endpoint. The mean endpoint total energy reduced across the control, N, NF, and NFS groups by 266, 215, 307 and 188 kcals respectively from baseline intakes. As this study included interventions targeted to reduce intakes, decreasing values of TEI were expected and comparable to other dietary change studies even if energy intakes were not the primary focus (Gatenby et al., 1997; Lapointe et al., 2009; Markey et al., 2016; Piernas et al., 2013; Raben et al., 2002). Reductions across all groups could be partially explained by the fact that all individuals were asked to follow some advice, even if only logging dietary intakes, as in the control group. A systematic review and meta-analysis into the effect of food intakes and eating awareness found that enhancing memory of food consumed reduced later intakes but not necessarily immediate intakes (E. Robinson et al., 2013). The authors concluded that 'attentive eating' likely influences intakes (E. Robinson et al., 2013). Research has also shown the impact dietary journals can have on weight loss to enact behavioural change. A study of 1,700 individuals found those who recorded daily diet diaries lost twice as much weight as those who did not record diaries (Hollis et al., 2008). This greater awareness of dietary logging likely impacted the reduction of intakes across the study. This dietary logging effect combined with the fact individuals who participated were volunteers perhaps contributed to effects seen in the control group.

This suggestion is supported by findings in the qualitative study where all individuals spoke frequently about increased awareness. Thus, the non-significant reductions in free sugars and significant reduction in TEI of the control group may be rationalised through the above mechanism.

For exploratory analyses into the dietary profile a paired samples t-test was run to compare baseline and endpoint mean percentage intakes of free sugars, carbohydrates, protein, fat and saturated fat, with only FS% found to be significant. Investigations in the 'CHOICE' swap-based intervention study found both intervention and control groups reduced total energy intakes across a six-month period, however they also reported significant reductions in total macronutrients, which was not found in this study (Piernas et al., 2013; Tate et al., 2012). Strict corrections applied to exploratory data within this study and the variation between total grammes and energy intake percentages may have contributed to the differences in these findings. The relationship between dietary fat and sugar has been described as a 'Sugar-Fat Seesaw' (Sadler et al., 2015). The authors state that there is an inverse relationship between sugars and fat (Sadler et al., 2015). It could be expected that as FS% significantly decreased across intervention groups, there would be a compensatory increase in fat. The findings of this study found that correlations between change in FS% to change in percentage protein, fat and saturated fat were non-significant, with only correlations to carbohydrates found to be significant. As discussed in their paper, the finding of a positive relationship between fat and sugar can be related to the influence of total energy intakes (Sadler et al., 2015). Although my research did not observe a direct relationship between fat and free sugar intakes, this could have been caused by multiple factors. Firstly, this study was not powered to observe a change in the relationship between fat and free sugar and therefore samples sizes may not have been sufficient to detect these changes. Secondly the niche effects of the recommendations being targeted towards free sugars specifically may have had an impact. For example, individuals changing free sugar intakes may have chosen from a variety of foods in replacement of free sugar items. The provision of advice regarding food swaps and substitutions in one of the groups may have limited the power to detect a significant movement in percentage changes between these two macronutrients. Individuals were therefore guided on their use of nutritional labels and food swaps which may have slightly impacted dietary choice for food items high in either sugars, fat or salt. Therefore, the dietary structure, nutritional advice and food groups recommended in N, NF and NFS groups may have impacted the reliance on only choosing high fat alternatives, with free sugar foods displaced for overall 'healthier' alternatives.

The hypothesis (H3) of 'Reductions in percentage free sugar intake will be associated to percentage fat intakes' is therefore rejected.

5.2.3. Taste status

Individuals were classified in this study as either sweet likers, inverted U, or dislikers using methodology as outlined by Iatridi (Iatridi et al., 2019b, 2019a). In addition, taste perceptions of bitterness categorised participants as super tasters, medium tasters or non-tasters of PROP (Bartoshuk et al., 2005; Green et al., 1993). At baseline there were no significant differences between groups in any taste status categorisations. When all participants were analysed, there were no significant correlations between sweet liker status OR supertaster status with summative adherence, baseline SQ attitudes, baseline free sugars intakes or baseline total sugar intakes.

The non-significant findings in this study differ from investigations by Garneau et al. (2018) although different AHC sweet liker categorisation was used as suggested by (Methven et al., 2016). In Garneau et al's, 2018 study investigating sweet liker status and beverage intakes, adult sweet likers were more likely to have higher energy intakes from SSB such as sweetened juice and tea (Garneau et al., 2018). In my research the classifications of sweet liker status used newer simplified methodology from (Iatridi et al., 2019b, 2019a) which may account for some discrepancies however, the large number of individuals assessed likely enhanced the power of my findings. Further, in this study it is possible sweet liker perceptions using the trialled and corrected taste paper method were assessed inaccurately in home participants, as liking for taste paper 'A' (sucrose paper) differed significantly between BU and home partaking individuals. The literature adequately assessing sweet liker status with dietary sugar intakes is limited in its comparability. In the most recent reports from Armitage and colleagues, the authors report their results, with the surrounding literature limited to support the idea that sweet liking may drive overconsumption of food high in sugar (Armitage et al., 2023). In the assessment of literature there are only 5 studies

(Garneau et al., 2018; Holt et al., 2000; Iatridi et al., 2020; Methven et al., 2016; Turner-McGrievy et al., 2013) that assess the relationship between dietary intakes and sweet-liking phenotypes (Armitage et al., 2023), of which only one utilised 24hour dietary recalls (Turner-McGrievy et al., 2013). In the study by Turner-Mcgrievy et al. (2013) it was found that sweet likers had increased intakes of caloric sugar-sweetened beverages and reduced fibre intakes. There was unfortunately no assessment of total sugars, free sugars or added sugars, with interaction between carbohydrates and sweet liker status non-significant (Turner-McGrievy et al., 2013). This finding indicates that the relationship between taster status and intakes could be more food specific rather than in a direct relationship with nutrients. This would be supported by the significant finding between the higher intakes of sugar in sweet likers as reported by Holt et al. (2000). Furthermore, it is reported that the majority of significant findings between sweet liker status (phenotype) and intakes appear to be detectable in increased sweet beverage intakes, or as assessed in FFQ methodology studies which could be said to be more heavily reliant on reported intakes of specific food and beverage intakes (Armitage et al., 2023). Overall, the research of this study is one of the first large sample size investigations into the sweet liker phenotype with dietary intakes as assessed in a 3-day food diary. As intakes of specific foods groups such as sugar-sweetened beverages alone were not accounted for it is suggested that perhaps relationships in sweet liking are more food group specific than nutrient specific. In analysing baseline variables in the lab subgroup, liking for taste liquid A (1M sucrose liquid) had a weak significant association to FS% of 0.185 $p<0.05$. Associations between sweet liker status and adherence were investigated, however sweet liker status did not influence adherence across all intervention points. Due to the absence of significant correlations between sweet liker status and baseline intakes of free sugar and total sugar this finding was reasonable. ***The hypothesis (H4) of 'Sweet liker status and supertaster status will be associated with sugar intakes' is therefore rejected.***

5.2.4. Knowledge, attitudes and behaviour

The role of knowledge and attitudes in determining dietary behaviours is highly debated. A recent review by Gupta et al. (2018) confirms that this is also the case for associations between attitudes and knowledge and sugar intakes specifically. The depth of research into correlations between attitudes and sugar intakes is limited, however initial findings suggest any impacts of knowledge and attitudes on sugar intakes is likely small, with more meaningful changes in sugar intakes likely to be derived from interventions external to individual factors (A. Gupta et al., 2018a). Direct comparisons between the data generated in this study and previous investigations of knowledge and attitudes associations to sugar intakes is challenging due to quantification of sugar intakes by sugary food or beverage consumption (Gase et al., 2014; Y. Lee & Joo, 2016; Park et al., 2013) compared to complete percentage sugar intakes used in this research. This study found the sweet attitude factor PC3 negativity had a weak negative association to FS% of -.194 $p<0.0001$ at baseline with no association found between total dietary knowledge or sugar recommendation knowledge. This finding must be viewed in light of PC3 having a report Cronbach alpha score of $\alpha = 0.69$. This alpha score was below the prespecified 0.7 value, with the questionnaire included due to it's relevance to this research. Further exploratory investigations found no significant correlations between change in sweet attitudes for PC1-PC6 to endpoint FS%, waist circumference, bodyweight, or total energy. This research supports the viewpoint that any associations between knowledge, attitudes and intakes are likely marginal with more investigations suitably powered for this exploration into this area needed.

The three-factor eating questionnaire is a valid and helpful tool in the assessment of eating behaviours. Lauzon et al, (2004) reported that the three sub score components in the TFEQ-R18 (CR, EE and UE) were association to sugary food consumption, with a positive correlation between EE and snacking food intakes. Data analysed in this research did not report any baseline associations between TFEQ and FS% with none of the sub score components contributing to the linear regression models FS1, FS2 or FS3. This research did find significant moderate negative associations (>-.202, p=0.001) between the TFEQ-EE and TFEQ-UE scores with baseline bodyweight, waist circumference and total energy intakes. It was also found that the TFEQ-EE significantly added to linear regression models for endpoint bodyweight ($BW2_{All}$), waist circumference ($WC2_{All}$) and total energy ($TE2_{All}$, $TE3_{All}$) at 12-weeks. These findings differ from some of reported literature where there was no correlation found between EE and bodyweight (Wrzecionkowska & Rivera Aragón, 2021) however, some evidence did report positive correlations (Anglé et al., 2009; Keskitalo et al., 2008). In research by Keskitalo et al., (2008), the authors highlight the impact of both genetic and environmental influences on this relationship suggestion that TFEQ-EE and bodyweight findings are dependent on the context they are collected. More research is needed to clarify this relationship in a western population of high sugar consumers.

In relation to the factors discussed above the following section in **Hypothesis (H5) of '*Attitudes and behaviours…. will be associated with free sugar intakes, physical anthropometrics, and total energy intakes'* is therefore only partially accepted**.

5.2.5. Analyses two

In subgroup investigations on the effects by recommendation type by BMI, sweet liker status and supertaster status, analyses were either non-significant or did not add to findings reported in analyses one. A report of these tests is included in Appendix 13. Further sub-group analyses by gender could not be completed due to the majority female population recruited in this study. In analyses one model $BW3_{All}$ found both group and gender marginally contributed to endpoint bodyweight. For model BW2, it was observed the demographic variable of occupation added significantly to the prediction however, when added to BW3 this was no longer a significant contributor. Current literature supports the view of an existing relationship between SES (Warren et al., 2022, Bolt-Evensen et al., 2018) and gender (Jiang et al., 2020) with SSB consumptions patterns.

At baseline it was observed that measures of physical activity from the GSLTPAQ were significantly negatively correlated with both bodyweight and waist circumference. These findings are in line with the current literature showing a relationship between increased physical activity and reduced anthropometric measurements (BMI, bodyweight, and waist circumference), with the inverse also reported (Dalene et al., 2017; Hamer et al., 2013). It was also found in this research that SF36 physical component summary (PCS) were negatively correlated with bodyweight and waist circumference. While no study to my knowledge has specifically focused on associations between the SF36 PCS and anthropometric measures, initial reports indicate that higher bodyweight and waist circumference are associated with decreased SF36 physical component summary (PCS) (Wee et al., 2008). Further baseline associations found the SF36 mental component summary (MCS) was negatively associated with FS% intakes. Investigations into these associations are limited however evidence suggests that unhealthy dietary patterns and intakes of ultra-high process foods may be inversely related to mental health and depressive symptoms(Jacka et al., 2014; Lane et al., 2022).

In light of the moderate findings from this study in relation to demographics variables, **Hypothesis (H5) of** 'Attitudes and behaviours, demographic and lifestyle variables, taste outcomes and food outcomes will be associated with free sugar intakes, physical anthropometrics, and total energy intakes' **is partially accepted.**

5.3. Tertiary objectives

- 3.0: To identify barriers and facilitators to intervention success in a subset of study participants.

The purpose of this framework analysis was to identify the barriers and facilitators to dietary change. Elucidating on participants experiences when asked to follow a free sugar reducing dietary recommendation. As part of this theses' tertiary outcomes, discussion of the themes identified is provided, with commentary added for analyses of intervention groups, interview time points and adherence scores (Boxall et al., 2022).

As part of the framework analysis the following seven themes and fourteen subthemes were identified; 1. Proof and impact (limited impact, seeing proof), 2. Realities of life (facilitators, barriers), 3. Personal balance and empowerment (balanced, unbalanced, empower, disempower), 4. Habitual approach (active, passive), 5. Is it possible?, 6. Extensive awareness and viewpoint, 7. Power of knowledge (enables, disables).

5.3.1. Themes discussion

To undertake a dietary intervention, it may first be necessary for individuals to consider if the recommendation is achievable. Expressed in the theme '**Is it possible**?' the context of responses are perhaps more specific to this study however, nearly all expressed the sentiment that the recommendation they received was generally achievable. In the SOC model, the factor of commitment to dietary health was found to be significant for dietary 'action' and 'maintenance' stages (Kelly, 2011). Importance of dietary health was more relevant for precontemplation and contemplation SOC, with confidence in ability to make changes non-significant (Kelly, 2011). Our theme '**Is it possible?'** had no large observable differences across group or interview timepoint, which aligns with reports by Kelly, 2011 that confidence in personal ability to make dietary changes is potentially minimal.

It is acknowledged achievability may be impacted by existing knowledge base, or perceived ease of accessing the information needed, such as through food labelling and nutritional informational as expressed in the theme **Power of knowledge**. Literature has shown individuals exposed to nutritional educational materials having improved knowledge, motivation for change, and feelings that nutritional modification would be easier than those not exposed to materials (Ardoin et al., 2022). Early research reported the inverse of this, with a lack of knowledge identified as a potential barrier to dietary change (Buttriss, 1997). It is likely that some participants benefitted from the additional knowledge provided in this study whereas others may have already been informed with this not contributing to differences. Although the methods employed to investigate this were study specific and not validated, it is likely that any differences were likely too subtle for the sample size to detect.

Recent observations report that individual factors such a 'desire for knowledge' to be important for intervention adherence, and negative attitudes towards guidance a hindrance (Deslippe et al., 2023b). This personal aspect of dietary change is reflected in the theme '**Personal balance & empowerment'** wherein an individual's personality and attitudes can be linked to their health behaviours. The perception of being empowered or in control has been linked to the practice of health behaviours such as eating healthier food and exercising more (Cobb-Clark et al., 2012; J Stewart–Knox et al., 2021). However, these habits of healthier diet and exercise may in turn positively impact our mental health (Grave, 2020) further increasing personal capacity for change. Despite the suggestion that these personal factors likely impact individual dietary intakes this study found limited quantitative data to support associations between attitudes, knowledge and free sugar intakes. Further research has found that elements such as knowledge, identity, beliefs, and emotions may influence reductions in free sugar consumption (Rawahi et al., 2018). The study by Rawahi et al (2018) outlined participants reports from the question of potential barriers and facilitator to change but did not include reports from individuals attempting to achieve the <5% FS% recommendation and therefore is itself limited. Due to the prevalence of 'individual' factors in adherence to dietary interventions (Deslippe et al., 2023b) it is likely that these did contribute to results in this study. However, as has been acknowledge by previous reports (A.

Gupta et al., 2018a) the contribution of factors such as attitudinal alterations on actional change were probably marginal.

In a recent systematic review of 35 qualitative studies into the barriers and facilitator to behavioural intervention adherence, the 'environment' was identified as a substantial contributor (Deslippe et al., 2023b). This echoes the sentiments identified in this research under the theme '**Realities of life'**. Participants described the impact of both individual and societal factors that impacted adherence to recommendations. This included factors such as cost; accessibility, social support, societal habits; time and work considerations. It is acceptable that the environment and society in which we live is likely to impact adherence to dietary recommendations (Bowen et al., 2015). It has been observed that our environment impacts factors such as the availability, convenience and affordability of food (Herforth & Ahmed, 2015; Popkin et al., 2005; Atanasova et al., 2022). Results from a global taxation review on sugar sweetened beverages, found that national tax strategies were associated to reducing rates of obesity and diabetes (Sassano et al., 2024). Furthermore, the wider impact of an individual's personal environment, including social, cultural and physical factors, impact dietary intakes (Kouba, 2005; Stroebele & De Castro, 2004; Vaughan et al., 2017; Wansink, 2004). Subtle factors such as food packaging size, eating location and ambience all influence food and quantity decisions (Stroebele & De Castro, 2004; Wansink, 2004). In the review by Deslippe et al, 2023, the authors report that the cost of foods was only mentioned as barrier to intakes. This differs from this research in that participants commented on the cost and accessibility of healthier alternatives being needed with participants describing it to likely enhance dietary adherence. It could be that because this study had a primary message of a food restriction within a food categorisation often utilised for 'snacks' that individuals were more considerate to the substitution and choices available for this than just the wider diet.

The themes already mentioned being, **Is it possible? Power of knowledge**, **Personal balance & empowerment,** and **Realities of life,** likely all contribute in some way to the expression of the theme **Habitual approach**. This theme outlines the approach individuals had to dietary change, with descriptions of, or absence of habit alternations included. It is recognised that all individuals recruited for this study required a certain level of commitment to participate in a dietary trial for 12 weeks. This is unsurprising given the voluntary aspect of participation being a known factor for the types of individuals who put themselves forwards for research of this nature (Young et al., 2020a). Therefore, the individuals expressed in this research are likely more motivated to change or undertake dietary adaptions or behaviours than the general population. An example of the connected nature between these themes is that, in an '**Active - Habitual approaches',** individuals may have undertaken additional research or investigation into the contents of sugary foods. This additional information may then enhance knowledge as expressed in the theme '**Power of knowledge'**. With further knowledge potentially enhancing perceptions of achievability of recommendations in '**Is it possible'.** This is of course theoretical and not categorically proven in this study, however, is mentioned to contribute to the discussion that although themes are often discussed in isolation they are likely interconnected.

Being aware of our dietary intakes as well as the influence of family, friends and the government was outlined in the theme **'Extensive awareness and viewpoint'.** The concept seems abstract, but general awareness of intakes or the considerations of diet may have a strong impact on any changes observed**.** For example, investigations into dietary recording have consistently shown the recording of dietary intakes improves factors such as nutritional knowledge, food choice, portion size, and awareness of diet-disease relationships (Chung et al., 2014; Doumit et al., 2000). This research echoes these findings in that all groups, including dietary logging only (control) provided commentary for increased dietary awareness. The potential impact this 'increased awareness' has on our physical outcomes has been shown in literature, with individuals who recorded diet diaries observed to lose double the amount of weight as those who did not (Hollis et al., 2008). Although such large differences between groups were not found in this study's quantitative analyses, all groups did reduce their reporting of total energy intakes from baseline to endpoint. It is hard to quantify how much of these changes in intakes can be attributed to awareness. Especially given the consideration that there could be differences in reporting due to respondent fatigue, different interventions received, misreporting, or preferential reporting linked to intervention aim (Abay et al., 2022; Kirkpatrick et al., 2018; Westerterp & Goris, 2002).

The final theme to discuss in this section is **Proof and impact,** which can be described as the ability to observe impact or not as a result of changes or intervention adherence. This aspect of '**proof**' is likely influenced by the concept of decisional balance within the stages of change (SOC) model (JO et al., 1994; Prochaska & DiClemente, 1983). At the beginning of behavioural change, the negative aspects of healthy behaviours are likely high. However, as adherence progresses this perceived cost may reduce. The inverse being true for positive aspects, which are initially low but then increase and out-weigh the negative (JO et al., 1994; Prochaska, 1994). This change in decisional balance allows for the emergence of positive aspects of behavioural change. Previous research has shown that observational changes signal intervention effectiveness and aid in adherence reinforcement (Deslippe et al., 2023b). With the top motivators for dietary change being for health, weight loss, self-image, social pressure and general wellbeing (Hagen Helland et al., 2021; Ljubičić et al., 2022; Satia et al., 2001; Van Uffelen et al., 2017). This study acknowledges the duality or proof to impact adherence, with those '**seeing proof**' more likely to continue with changes, and those with '**limited impact**' more likely to discontinue or give up. Changes in visible bodily awareness, e.g. weight loss, or the integration of changes on factors such as increased energy are reported as facilitators. Whereas no observable differences can be thought as barriers with individuals most likely demotivated in continuing with the dietary advice (Deslippe et al., 2023b). In the quantitative analyses there were marginal findings regarding the reduction of bodyweight across intervention groups with respective reduction in waist circumferences. Significant reductions from baseline to endpoint across FS% intakes in the intervention group but not the control were also found.

5.3.2. Study group

In general, all participants interviewed across groups were aware of the same overarching themes. There were however differences in the control group commentary being more generalised and less personal to the individual. For example, awareness of dietary intakes was likely increased for all, due the impact of dietary logging as seen in literature (Hollis et al., 2008). However, responses from intervention groups were more specific regarding, food choices, dietary changes made, with comments on food labelling and quantifiable intakes. Some of these findings can be rationalised via the use of the intervention vs control methodology. Intervention groups were provided with more knowledge from booklets in addition to a percentage recommendation surrounding free sugar intakes. Whereas the control group were simply requested to record their dietary intakes.

It was likely that having a target for dietary change in the intervention groups allowed participants to focus on the specifics of what foods, foods groups and dietary behaviours they needed to change, with an enhancement to food knowledge in this area. A non-randomised intervention trial into the impact of nutritional knowledge on eating habits and anthropometric markers found that increases in knowledge using a FCQ, was linked to significant reductions in sweets, soft drinks and processed meats, with subsequent 3% reductions in bodyweight were also observed (López-Hernández et al., 2020). Therefore, as the control group likely became more aware of dietary intakes, some adjustment would be seen, however they would not share the specificity for increased knowledge and dietary changes that the intervention groups did. This is particularly evident in comments surrounding a quantifiable goal. Individuals in the intervention groups expressed how having knowledge of their specific baseline intakes would help when meeting a percentage nutrient goal. With this type of commentary absent in the control group.

Comments from the NF and NFS tended to be more integrated regarding the bodily impacts, with commentary regarding the physical changes such as weight less, increased energy and general wellness reported. These qualitative expressions are supportive of quantitative results in the larger anthropometric reductions seen in the, N, NF and NFS groups than control group. Although differences between the groups were not statistically significant. The impact of these visible changes likely reinforced behaviours and were facilitators to dietary changes (Deslippe et al., 2023b). The overall likely increase in knowledge for the intervention groups, combined with larger observations and reporting of physical changes likely enhanced motivation (Ardoin et al., 2022) and adherence (Deslippe et al., 2023b) in the NF and NFS intervention groups specifically.

5.3.3. Interview timepoint

The collection of qualitative data was conducted across the whole 12-week study period, with individuals in all groups interviewed at all timepoints to ensure a representative sample. In interviews conducted at earlier timepoints, the language used to describe dietary habits included changes participants were going to make or thinking about making. In comparison interviews at later timepoints appeared to provide more commentary about the changes that had already been made and were more specific. It could be theorised that individuals once enrolled in the study may transition into a ‘preparation phase’ as outlined in the SOC model. The ‘preparation phase’ describes individuals as being committed to making a change but not yet completing it, as expressed in the language of individuals thinking about changes (Ni Mhurchu et al., 1997). As participants progress through the study the transition to the later ‘action’ phase of the SOC model are likely. The ‘action’ phase is described as the successful change in behaviour (Ni Mhurchu et al., 1997); therefore, it would be rational to attribute the increased commentary about specific changes made as reflective of more individuals being at latter SOC phases in week eight and twelve timepoints.

Comments on physical changes such as increased energy, reduction in bodyweight and to the taste changes of foods were more prevalent from week four. The taste change comments did however occur from the first interview week but to a lesser extent. It has been observed that alterations in dietary intakes from nutritional interventions may result in taste perception changes (Micarelli et al., 2021). Specifically in the paper by Wise et al, 2016 it was shown that reduced intakes of sugars altered the perception of sweet taste intensity at twelve weeks (Wise et al., 2016). It is however surprising that reports of taste change in my study were present from the first week. It is surprising because sweet perception was only altered from as early as eight weeks in the study by Wise et al, 2016. As all individuals completed taste tests at their first study day, it could be suggested they were primed to be sensitive to taste changes and therefore a placebo type of effect may have taken place (Wise et al., 2016). In a review of sweet taste exposure and preference for sweet taste it was reported that short-term interventions of increased sweetness exposure tended to lower preferences, with evidence from four RCT trials supporting the inverse of lower exposure leading to increase perceived sweetness intensity (K. Appleton et al., 2018). It could therefore be theorised that as individuals attempt to reduce intakes of free sugar foods, they become more attuned to sweet tastes. By having decreased exposure to these food items, sensitivity may then in turn be increased (K. Appleton et al., 2018; Wise et al., 2016). Furthermore, in a study assessing motivation and weight control it was found that both autonomous and controlled motivation increased during the first four weeks, with individuals reaching their bodyweight goal maintaining these motivational levels at sixteen weeks (Teixeira et al., 2012). Although this study was not aimed at weight loss, it is likely that individuals had their own motivations for taking part such as health, weight loss, improved self-image and general wellbeing (Hagen Helland et al., 2021; Ljubičić et al., 2022; Satia et al., 2001; Van Uffelen et al., 2017), with this sentiment reflected in qualitative results for '**seeing proof**'. On achievement or partial achievement of personal goals at four weeks, individuals may have then been incentivised to continue with dietary changes with motivational levels maintained. Therefore, in future interventions this may present as a key timepoint for reviewing dietary changes made and the personalisation of future recommendations provided.

The challenge of nutritional disinformation from the media, internet and food industry has been noted as a health communication challenge with not all individuals having the health literacy available to critically evaluate information presented (Silva et al., 2023). Participants in this study across all timepoints included criticism of the industry for being misleading and deceptive. In addition, those interviewed at latter timepoints made notable criticism of food labelling being poor, with connections to industry and government highlighted. In the UK, food labelling does not currently include 'free sugar' specific nutritional information on its labels. Labels are written in terms of 'Of which sugars' and 'Total sugars' (Department of Health, 2016; of Health, 2016). Therefore, intervention group participants likely had to combine looking at ingredients lists and the non-free sugar specific labels to estimate how much a product contained. These reports reflect the wider environment in which participants found themselves, highlighting the need for more consistency to be given between dietary guidelines and food labelling, so as not to disadvantage individuals and favour industry. It would be suggested that whenever the next review of UK dietary guidelines and or food package labelling occur, that this process be integrated to consider both of these respective factors. This could then hopefully produce labelling formats that directly align with governmental dietary guidance, helping the public to make the most informed decisions possible regarding their intakes.

5.3.4. Adherence score

In the assessment of adherence score it was found that individuals with higher SA scores were often more confident in their recommendation. A few individuals with lower adherence scores reported confusion over recommendations provided. This could have been because individuals with higher SA scores tended to belong to NF and NFS intervention groups, with those in the control groups most likely to have lower reported SA. It has been reported in literature that personal confidence in your ability to make changes is potentially minimal in its impact for the SOC model (Kelly, 2011). In the nutrient intervention group, who received the least amount information, there was still a proportionally higher number of individuals with SA scores of three or more. This implicates that across the intervention groups, the amount information provided may not have substantially impacted an individual's ability to achieve the recommendations. Linked to this idea of information provided, and potentially knowledge gained. Individuals with higher adherence scores of three and above provided additional comments regarding their further expansion and research of knowledge. It could be suggested that those who did greater research around their recommendation expanded their knowledge, benefiting from being further motivated for change, or then potentially viewing changes as easier (Ardoin et al., 2022). Furthermore, those who did not complete this additional research and personal investigation may have been at more of a disadvantage to achieve recommendations (Buttriss, 1997). It is suggested that the act of doing further research itself may be a contributing factor to achievement of dietary recommendations, with it theoretically showing an element of personal investment.

In individuals with scores of SA two or more, there was reporting of physical changes such as increased energy, weight loss and improved skincare. It is suggested that this finding may be due to the higher numbers of NF and NFS intervention group participants represented under the higher SA scores. In quantitative results, those with higher SA scores, compared to lower, had reportedly bigger decreases in free sugar intakes, with some indication this aligned with changes in anthropometric measures. The impact of observable intervention adherence may have enhanced individuals from the studies mid-point to maintain their efforts (Deslippe et al., 2023b). It would be rational to expect those that were most adherent would be seen as the largest anthropometric changes and be from the intervention groups that reported this. Moreover, as reports of these physical changes also notably increased from week four the opportunity for high autonomous or controlled motivation to remain elevated until the twelve-week study end was more likely in these groups (Teixeira et al., 2012). Theoretically the element of adherence and consistency in dietary change is perhaps one of the most important factors.

5.4. Finding overview

The study demonstrates that reducing free sugar recommendation interventions can reduce free sugar intakes at an endpoint of twelve weeks. It is likely that the recording of diet diaries impacted all individuals to some degree with those in the control group still seeing reductions in FS% intakes, TEI, and anthropometrics, although often non-significant. This is reflected in interviews where all groups commented on increased dietary awareness and changes seen however, intervention groups were more precise and personalised in comparison to the general comments the control group provided.

Further to this, the quantitative results indicate that greater adherence was important for reductions in both nutritional and anthropometric outcomes. This again is somewhat supported in interviews conducted, with those of mid to high SA scores providing commentary on the physical changes seen. It was surprising that taste changes occurred from the first week, however as discussed above, it could be said that indirect effects such as 'placebo' or 'expected changes' may have played a part in the earlier reporting of this.

Changes across time from qualitative interviews seem to reflect the increased awareness, for example, changes from 'trying' to do something, or not-understanding, are resolved in latter weeks. This also presented as some criticism from individuals becoming more aware of recommendations in the context of society. These factors may have contributed to the only slightly bodyweight reductions observed across the groups, with the quantitative findings suggesting only a potential a trend.

Overall, this study demonstrates that interventions to reduce free sugar intakes are effective, with adherence and awareness key components contributing towards success. It is evident that wider social, sociodemographic and lifestyle factors remain a challenge for all individuals, irrespective on their achievement of recommendations at 12 weeks.

5.4.1. Limitations

Underreporting

Underreporting of dietary intakes in diet intervention studies are common (Biró et al., 2002; Ravelli & Schoeller, 2020; Wehling & Lusher, 2017), especially sugar containing items (Krebs-Smith et al., 2000; Price et al., 1997). The issue of underreporting was approached by the researcher sending a reminder to log dietary intakes at the time of eating on the morning records should be generated, in addition to prompts to complete diaries if data was evidently missing the next day. Underreporting in terms of portion size was controlled for across the study via the nature of the Nutritics Libro dietary logging platform (Nutritics, 2019b). The 'Libro' app provided participants with portion size suggestions and images for the most commonly consumed foods and drinks, presented uniformly to ensure knowledge of grammes and intakes was less limited. Due to the length of the study and the number of food diaries that were requested, some participant fatigue in dietary logging could have occurred (Nutritics, 2019). Any bias from logging fatigue was also controlled for as best as possible by presenting and interpretating results in percentage energy intakes and utilising multiple imputation for missing data. In additional systematic calculations of free sugar intakes food substitutions from one database across all diet diaries helped ensure the validity of findings in FS% intakes was retained.

In this study baseline energy intakes varied across the groups from 1683 – 1782 kcal. Baseline energy intakes were comparable to the reported UK average energy intakes from the NDNS programme Years 9-11 in adults aged 19-64 years, which were 7.69 MJ/day, equivalent to 1838kcal and women aged 19-64 years which were 6.75 MJ/day, equivalent to 1614kcal. As reported earlier, the current average BMI for adults across the UK was 27.5 kg/m2 in 2011, with 37.9% individuals overweight and 25.9% obese (NHS Digital, 2022). These bodyweight findings are comparable to the participants observed in this research which had an average BMI of 27.72±5.73 kg/m2, with even proportions of lean, overweight, and obese BMI individuals 35.1, 35.1 and 29.8% respectively. Therefore, although initial energy intakes may appear to be below weight maintenance, the validity of reported dietary intakes from individuals in this study with a similar BMI to national levels is equivalent to that of dietary data gathered in the NDNS dataset. Energy intakes in this research are also comparable to the study by Markey with reported baseline intakes of 1895-1916kcal utilising a 4-day weighted foods diary including 3 weekdays and 1 weekend (Markey et al., 2016). One difference accounting for the slightly higher average in Markey is the higher proportion of men to women that took part at 32% (16 males, 34 females) compared to this study at 11.57% (28 males, 214 females) (Markey et al., 2016). Another study by Tate et al, and reported by Piernas et al, of higher female participants reported baseline intakes of

2056 – 2283 kcal, however dietary intake data were collected at baseline, 3 months and 6 months by trained interviewers by using 2 unannounced, telephone- administered 24-h recalls (Piernas et al., 2013; Tate et al., 2012). Dietary data included one weekday plus one weekend day within a 14-d period (Piernas et al., 2013; Tate et al., 2012). These difference in participant demographics, and methodology plus the known issues of underreporting and the controlling mechanisms in data analysis utilised in this study strengthen the results found and reported. This factor was considered in the design of this research via the inclusion of a control group which were instructed to only record their dietary intakes. As all intervention groups and the control recorded dietary intakes in the same manner the impact of increased dietary awareness on dietary logging, intakes and the further data analysis was controlled for.

Selection bias

This study was advertised for those interested in dietary change and used a dietary app to record intakes. Individuals who took part were willing volunteers and therefore potential less reflective of the general population. Previous research has shown associations between voluntary participation and health behaviours (Cheung et al., 2017; Enzenbach et al., 2019). Enzenbach et al. (2019) observed that individuals who voluntarily participated in their research study had significantly higher income levels, education status, marriage status and subjective health. Therefore, individuals who took part appeared to be more health conscious or were already engaged in behaviours to improve health. As Young et al. (2020) state, studies that recruit volunteers are potentially limited in their generalisability to the wider population (Young et al., 2020a). It was suggested that when investigating specific nutrient effects within the context of baseline participant characteristics, baseline diet screening diet at the nutrient level should be completed a-priori (Young et al., 2020a). Although published after the start of this trial, the methodology (Young et al., 2020a) suggested of a pre-screening to enrolment was employed in this study to mitigate these potential selection effects, with only individuals screening to have FS% intakes >5% eligible for study inclusion. In addition, individuals were not provided with financial compensation to decrease the risk of bias which has been shown to be impacted by participation from financial incentives (Frey & Oberholzer-Gee, 1997).

Timing

In this research study, participants were monitored for a 12-week period with no follow-up after. Test days were completed at the start and end of the 12-week period. The choice to not complete additional bodyweight measures except at test days was chosen to limit impact on the intervention itself. As part of this PhD project the researcher was to have limited contact with participants to ensure individuals did not accidently reveal their allocation. Participants attending their second test day via zoom or the lab, which involved anthropometrics recording, did so within 4 weeks of their last diet diary. This 4-week period may have been too long and negated some bodyweight effects seen as individuals no longer considered themselves to still be following the dietary advice. The results found in this study regarding bodyweight may have been reduced due to this wash-out period. However, this is perhaps more reminiscent of real-world effects where some individuals would continue with the dietary changes and others would not. This suggestion is supported by evidence from literature that in free living individuals consuming ad libitum diet, free sugar or SSB intakes are a determinant of bodyweight (Morenga et al., 2013). Therefore, it is possible that bodyweight reductions at 12-weeks may have been larger across the groups. In relation to timing limitations, there was no follow-up period included in the study. This was due to the 12-week design already incorporating a period of reduced dietary recording between weeks four and twelve to compensate. Further follow-ups at months six and twelve would have been ideal however, were outside the scope and capability of this PhD research project.

Sweetener bias

As outlined in the introduction of this thesis, public perception of non-nutritive sweeteners can often be negative (Farhat et al., 2021). In participant interviews perception of sweeteners, artificial foods and fake products was commented on across all groups and interview timepoints. Comments were rarely positive, with most referencing the avoidance of these food items, or highlighting how they perceived them to be damaging or unfavourable in some way. Despite the NFS group receiving information on the safety of sweeteners, it could be that the inherent negativity towards sweeteners limited the food choices individuals within this intervention group could have made. This in turn could provide more reasoning to why the reductions in the NF and NFS groups were on par.

Qualitative analysis

Interviews were gathered accounting for study group and study timepoint. This resulted in a large number of interviews conducted and data collected. Due to this the summarising of data across themes and sub themes and subsequently by group, interview timepoint and adherence score, were time consuming. The large number of responses required additional summaries to be made as the first summarised matrices were too unwieldly for analyses. Further to this, in descriptive comparisons by adherence group, it was likely that as interviews had been conducted based on study group and timepoint, there was too much noise to focus on targeted variations in commentary.

As with all qualitative investigations, this work can be impacted by researcher subjectivity. The influence of a researcher's personal beliefs, intuition, and interpretation can introduce bias, with numerous judgements required. In the generation of themes for the identification of barriers and facilitators, multiple reviewers were included in minimise the influence of any one researcher's bias. However, the summarising of data for the commentary of variation between group, interview timepoint and adherence score was only completed by one researcher with additional verification needed before peer review publication (Morse et al., 2002). Finally, Framework analysis has been criticised for lacking the same theoretical foundations as alternative qualitative inquiry e.g., grounded theory (Ward et al., 2013) and potentially suppressing interpretive creativity inherent to qualitative investigations (Dixon-Woods, 2011; Ward et al., 2013). Despite these criticisms, the basis of utilising Framework analysis was centred around its ability to interpret themes across phenomenon of interest. Additionally, the aims of this researched aligned with the contextual, evaluative and strategic principles underpinning Framework analysis (Gale et al., 2013; Ritchie & Spencer, 2002).

5.4.2. Future studies

This current research can be interpreted as a first step in understanding the effectiveness of different FS% reducing dietary guidelines. The intervention focussed on one change for participants with the dietary advice taken from NHS choices, diabetes UK and Public Health England (NHS, 2018, 2019b; Diabetes UK, n.d.-b). This study found there was a significant decrease in FS% in all intervention groups at 12 weeks from the delivery of N, NF and NFS dietary advice vs the control of food logging alone. It is suggested that future research targeting dietary advice for FS% reductions should be conducted over a longer period of time, include repeated anthropometric measurements and test different types of FS% reduction messages e.g., advice tailored to tastes or targeting multiple nutrient groups. The investigations of this research revealed that the UK's government advice is effective at reducing FS% intakes however, it is suggested that further research testing the effectiveness of the whole Eatwell guide (Public Health England, 2016b) be completed in free living individuals consuming ad libitum diets. Furthermore, the UK government should revise dietary guidelines and food labelling to better reflect the needs of the UK population. In order to generate effective dietary advice, we need to expand the current literature, to understand what works to produce dietary change, and what is ineffective. Once we understand the effectiveness of current advice, psychological theory may be applied to enhance these already familiar messages.

5.4.3. Context

In the UK (Public health England, 2020a) and internationally (Azaïs-Braesco et al., 2017), intakes of sugars still exceed recommendations optimal for health. Combined with the known adverse effects of high sugar diets on health (Huang et al., 2023a) and poor adherence to FBDG (Batis et al., 2012; den Braver et al., 2020; Leme et al., 2021; Culliford et al., 2023; Kebbe et al., 2021), this study sought to investigate to effectiveness of different free sugar reducing dietary recommendations. We learnt that simple targeted interventions and the current UK free sugar reducing guidelines are effective at reducing intakes. However, with only two countries (UK and USA) having distinct quantitative messages on sugar reduction (Herforth et al., 2019) it is clear more needs to be done at a global level to encourage national guidance. For the individuals participating in this study, it was designed to emulate dietary advice as if provided to them in the community. All intervention group participants were asked to reduce intakes of free sugars however one area of difficulty that cannot be overcome by recommendations alone, is the environment in which we live. Currently in the UK, nutritional labels only show 'Carbohydrates' and 'Of which sugars' however, 'of which sugars 'refers to all sugars within the food items and not specifically 'free sugars' (British Nutrition Foundation, 2022). Therefore, the UK governments own recommendation to reduce free sugars cannot be practically supported, with consumers having to assume the free sugar content of products from ingredient lists and ‘Of which sugar’ labels. In fact, advertisers can claim a product contains no ‘added sugar’ even if ‘free sugars’ have been formulated as part of the product. This confusing picture, and lack of information was picked up by participants in qualitative interviews undertaken as part of this research. The proper labelling of food and drinks is one area the UK government could directly aid consumers in helping to reduce intakes of free sugars. Further research on food labelling found particularly interpretative labelling to be an effective strategy for aiding with healthier consumer choices (Cecchini & Warin, 2016; Scapin et al., 2021). Moreover, the format of labelling is important for increasing consumer understanding (Borgmeier & Westenhoefer, 2009) and identification of high sugar foods with less obvious sugar labelling methods were missed by up to 47% of individuals in Falbe et al. (2023). Making sure these labels are visible will further aid reductions as not all products contain them. Furthermore, completing additional research in this area to include longer time-periods and different types of free sugar reducing messaging should aid in the production of future dietary recommendations.

The initial ambition of the UK governments Sugar Reduction programme was to achieve a 20% reduction in the sugar content of foods, and further helping to ease the burden of obesity (HM Government, 2016; Public Health England, 2019; Public Health England (PHE), 2017). At the end of year 4, the Office for Health Improvement, (2022) reported only a 3.5% reduction was reported. Despite the 20% not being achieved and many of its foundations still being relevant in today’s society of high sugar diets, the UK government has not announced further ambitions or targets related to the reduction of sugar intakes. It is clear that sugar intakes and its relevance to today’s society is still at the forefront with more legislative action, and research needed in this area to aid both the individuals and wider public.

5.5. Conclusion

This study sought to investigate the effectiveness of advice to reduce free sugar intakes. The free sugar reducing advice provided to participant significantly decreased intakes, however not to the desired extent of the <5% TEI FS% recommendation. It is likely this goal of <5% will be a challenge for much of the population to achieve if greater changes at a national level are not updated. A suggestion of a review of cohesive messaging between guidelines and labels is needed at a national level, however changes should not be limited to just this one suggested area. The evidence found in this trial supports the use of simple interventions targeted to promote gradual change, with adherence to advice a pivotal factor for long term dietary and physical benefit. Further research into the field of the effectiveness and personalisation of recommendations for individuals is needed. As the factors contributing to dietary intakes are often unique to the individual and their personal and external environment. Developing a way to identify these unique characteristics and delivering effective, targeted and personalised dietary advice for change at a broader national scale is needed rather than a one size fits all guide.

5.5.1. Researcher reflection five

Once all my data had been gathered and analysed the write up of this thesis needed to begin. Being the culmination of so much work, I began to feel both excited and anxious to see this completed. The process of writing this thesis was more challenging than I anticipated, requiring the revision of many chapters, again and again. Moving sections, reprioritizing content and constantly thinking about the big picture of how it all fits together. It was a giant puzzle coming together, but also a time to appreciate all that I had done. It may sound cliché, but I don't think I had really stopped to think about all the work I had undertaken across the past years. The PhD journey can often be lonely and a series of never-ending work for which you have sole responsibility. Friends, family and colleagues can be encouraging about your journey, but I don't think you really start to appreciate that until you are near its conclusion. In some ways I wish I had appreciated the journey more and not been as hard on myself. I can however sit here today and feel some sense of pride in what I have been able to achieve. Although this work is my own, it wouldn't have been possible with the support of all those in my life both professionally and personally who supported me.

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7. Appendices

Appendix 1: Protocol paper published for trial.

Protocol: The effects of nutrient- vs food- vs food-substitution-based dietary recommendations for reducing free sugar intakes, on free sugar intakes, dietary profiles and sweet taste outcomes: A randomised controlled trial. Lucy R. Boxall, Emily Arden-Close, Janet James, and Katherine M. Appleton

Abstract

Dietary guidelines are intended to inform and aid the general public, with the aim of improving healthy diets and reducing health risk. The effectiveness of these guidelines, however, is rarely investigated.

This work investigates the effects of three different types of dietary recommendations for reducing free sugars, on free sugar intakes over 12 weeks. Secondary aims will also investigate how these different recommendations affect secondary outcomes, outcomes in subsets of the trial population, and identify barriers and facilitators to dietary change.

Using a randomised controlled parallel-group trial with three intervention and one control arms, 240 individuals consuming >5% total energy intake from free sugars will be randomized to receive: nutrient-based, nutrient- and food-based, nutrient-, food- and food-substitution-based recommendations or no recommendations, with outcomes assessed for the following 12 weeks. Our primary outcomes are free sugar intakes and adherence to the recommendations. Secondary outcomes are daily energy intake, dietary composition, anthropometry, sweet food perceptions and preferences, sweet food choice, attitudes towards sweet foods, eating behaviour and food choice, knowledge and lifestyle variables, quality of life, adverse events, and barriers and facilitators towards intervention adherence.

Data will contribute to three distinct analyses: 1) Analyses to investigate the effects of the three different dietary recommendations versus control; 2) Analyses of the effects of the dietary recommendations in different population subgroups, and 3) Investigation of the barriers and facilitators to success.

This work offers new perspectives on the effects of different dietary recommendations to enact behaviour change.

Introduction

Extensive epidemiological evidence supports a relationship between dietary intakes and the incidence, prevalence and severity of non-communicable diseases (Afshin et al., 2019). Thus, the prevention and treatment of non-communicable diseases may be aided through greater population-based adherence to healthy diets (Brunner et al., 2007; Eriksen et al., 2018).

One strategy for improving diets on a population-wide basis is the provision of dietary guidelines. With the evidence for benefit primarily based on nutrients, early dietary recommendations focused on nutrient intakes, e.g., salt, fat, folate. These guidelines adapted nutrient daily reference intake values into simple messages for the public (Public Health England, 2016). The UK's salt reduction programme, for example, relied on simple nutrient-based recommendations (He et al., 2014). In combination with industry reformulation, and a straightforward monitoring programme, successful reductions in salt intakes and population blood pressure were observed (He et al., 2014), but progress has stalled since 2011 (He et al., 2019; National Diet and Nutrition Survey, 2020).

In 1998, the World Health Organization (WHO) and Food and Agriculture Organization (FAO) recommended that consumer guidelines should be based on foods, as foods, not nutrients, make up dietary choices and that encouraging changes to whole dietary patterns would benefit multiple single nutrient goals (World Health Organisation et al., 1998). National food-based dietary guidelines (FBDG) now exist in over 90 countries (Herforth et al., 2019).

The majority of FBDG are produced from scientific data, versions of previous guidance, and guidelines in other countries (Blake et al., 2018). For example, Public Health England (PHE) recently reformulated the UK's 'Eatwell guide' in response to a national free sugar reduction programme (Public Health England, 2014) and revised dietary recommendations (Scientific Advisory Committee on Nutrition, 2015). Linear programming of intake and food composition data were used to identify foods and food groups, and models were created to identify the fewest number of dietary changes required to meet national daily reference intake values (Public Health England, 2016). The new guidance was then evaluated for understanding in consumer research interviews (Public Health England, 2016), but no real-world field testing was undertaken. This lack of testing may contribute to low uptake and adherence to FBDG (Leme et al., 2021; Yau et al., 2019), suggesting a need for greater rigour in assessing the efficacy and effectiveness of FBDG (Brown et al., 2011).

Limited evidence also suggests that the use of food substitutions may aid FBDG. Pilot evidence suggests that campaigns around snack substitutions may enact dietary change (Juszczyk & Gillison, 2018), and online supermarket-based studies report benefits to the contents of shopping baskets by altering the order of the offered food and suggesting lower saturated fat options (Koutoukidis et al., 2019). However, other studies have found little benefit from food substitution strategies (Forwood et al., 2015).

The proposed study will investigate the effectiveness of nutrient-, food-, and food-substitution-based recommendations for reducing free sugar intakes. Increased consumption of dietary sugars and associations with increased risk of dental carries, non-communicable diseases and excess weight (Ahmad et al., 2020; Monnard and Grasser, 2018; Scientific Advisory Committee on Nutrition, 2015; World Health Organisation, 2015) have resulted in the recommendation that intakes of '*free sugars should not exceed 5% of total dietary energy'* (Scientific Advisory Committee on Nutrition, 2015: page 196). Effects of the differing types of recommendation will be assessed on free sugar intakes, dietary profiles and sweet taste outcomes in adults consuming >5% total energy intake (TEI) from free sugars.

Methods and design

This trial is a randomised controlled parallel-group trial with three intervention arms and one control arm. The primary purpose is to assess the effects of three different types of dietary recommendations for reducing free sugars, on free sugar intakes over 12 weeks, in individuals consuming >5% TEI from free sugars. Secondary aims will investigate how these different recommendations affect secondary outcomes, outcomes in subsets of the trial population, and will identify potential barriers and facilitators to dietary change.

Ethical considerations

The trial received ethical approval from the Research Ethics Committee of Bournemouth University, UK (ref: 30612) on 28.04.20 (with amendments approved on 29.03.21) and was registered on Clinicaltrials.gov (ID: NCT04816955) on 24.03.21. The trial will be run in accordance with the Declaration of Helsinki (1983), the Ethical Guidelines of the British Psychological Society, and Bournemouth University's Research Ethics Code of Practice. All participants will provide written informed consent prior to participation.

Participants

Recruitment and eligibility

We aim to recruit 240 male and female participants from the general community residing in the South of England. Individuals will be eligible for trial inclusion if they are: aged 18–65 years, consuming >5%TEI from free sugars, able to provide informed consent, and complete all trial measures, including those to be completed via mobile phone or computer. Exclusion criteria are pregnancy or breastfeeding; underweight (BMI<18.5 kg/m^2); pre-existing medical conditions affecting swallowing ability, taste and/or smell perception; currently, or within the previous three months of starting the trial, following a specific dietary programme; currently, or within the previous three months, smoking; pre-existing clinical conditions, including allergies, diabetes mellitus, eating disorders, Crohn's disease, leading to the use of external nutritional advice and dietary restrictions.

Sample size

Sample size equations are powered at 80% for an alpha of 0.05 to test for a 2% change in percentage free sugar intakes from baseline to trial end (Whitley and Ball, 2002). Due to a lack of literature on the use of dietary recommendations for reducing free sugar intakes at trial conception, sample size equations were based on the reported effects of a trial on the use of dietary recommendations for reducing saturated fat content (Smith et al., 2015). The highest standard deviation calculated from these data (SD = 2.4) was used to calculate a required group size of N = 46 per trial arm (Whitley and Ball, 2002). Allowing for a 20% drop-out rate and unequal recruitment across trial arms, we aim to recruit 240 people in total.

Randomisation

Participants will be allocated into one of four trial arms following baseline assessments, using stratified randomisation (Suresh, 2011), based on gender, BMI, and free sugar intakes (%TEI) at baseline, as variables that may affect our outcomes. Randomisation will be undertaken by a researcher with no direct contact with participants using a random number generator, before the trial start. Group allocations will be concealed using opaque sealed envelopes.

Intervention/control

There will be four trial arms: three arms delivering different types of recommendations for reducing free sugars and one control arm. All dietary recommendations have been gained from current publicly available information (NHS, 2018, 2019; Diabetes UK, 2021). All intervention / control instructions will be delivered to participants in a sealed envelope, alongside a user guide for *Nutritics Libro App* (Nutritics, 2019), and an instruction *'to keep an accurate diet diary using the Nutritics software*'. All groups will receive the same instructions regarding the diet diaries, but this instruction has been carefully worded, such that for participants in the control group, this instruction can be construed as a dietary recommendation. On receipt of their sealed envelope, all participants are also informed that we consider a dietary recommendation to be anything from simply recording your diet to the provision of specific instructions.

Group N: Nutrient-based Guidelines

The nutrient-based recommendations begin with the instruction: *'Your dietary recommendation is to reduce your intake of free sugars to less than 5% of your total energy intake'.* This sentence will be followed by one page of nutrient-based information, including the different names for sugars and how to identify the sugar content of foods, e.g., '*high in sugar – 22.5 g or more of total sugar per 100g'*. Current recommendations from PHE (NHS 2018) have been amended to provide only the nutrient-based information that relates to sugars, through the deletion of non-nutrient based information. Diet diary instructions then follow.

Group NF: Nutrient- and Food-based Guidelines

These recommendations begin with the instruction: *'Your dietary recommendation is to reduce your intake of free sugars to less than 5% of your total energy intake. To aid with this, reduce your intake of foods high in free sugar'.* Participants will then be provided with the same nutrient-based information as Group N plus four additional pages detailing which foods are commonly high in free sugars and examples of how much sugar is included, e.g. '*A bowl of sugary breakfast cereal could contribute 70g of sugar (up to 22 sugar cubes) to your diet over a week'.* Current recommendations from PHE (NHS 2018, 2019) have been amended to provide the nutrient- and food-based information that relates to sugars, through the deletion of nutrient and food-based information that relates to other nutrients. Diet diary instructions then follow.

Group NFS: Nutrient-, Food- and Food-Substitution-based Guidelines

These recommendations begin with the instruction: *'Your dietary recommendation is to reduce your intake of free sugars to less than 5% of your total energy intake. To aid with this, reduce your intake of foods high in free sugar and replace these with low sugar versions'.* Participants will be provided with the same nutrient- and food-based information as Group NF, plus five additional pages on low-calorie sweeteners (LCS) and low sugar versions of foods. This information details what LCS are, where they are found, their different uses, and suggests low sugar substitutions for high sugar products, e.g., *'biscuits – swap for oatcakes, oat biscuits, or unsalted rice cakes'*. This information has been gained from Diabetes UK (Diabetes UK, 2021) and includes only details on LCS with removal of all references to diabetes. Diet diary instructions then follow.

Control group

Participants in the control group will be given no dietary recommendations. These participants will receive only the instructions to keep an accurate diet diary.

Intervention delivery

Participants will be provided with their intervention envelopes following baseline measures. Participants will not be permitted to ask questions on their recommendations. This mirrors the current scenario for the UK public where dietary recommendations are provided, e.g., via government slogans and TV advertisements, without the opportunity to ask questions. An inability to ask questions will also ensure that the same information is provided to all participants, maintaining intervention fidelity. Activities undertaken to adhere to the recommendations by participants, e.g., information gathering, LCS use, will be assessed among the outcomes of the study.

Blinding

All envelopes containing the intervention and control recommendations will be identical, sealed and coded by the researcher undertaking the randomisation (KMA). All envelopes will be packaged to include the same number of pages regardless of intervention / control (through the addition of blank pages) to maintain researcher blinding. The researcher in direct contact with participants (LRB) will be kept blinded to treatment allocation throughout data collection. It is impossible to blind participants to group allocation, however, participants will be blinded to the true purpose of the trial and to all interventions other than their own. To further disguise the purpose of the trial, all participants will complete several questionnaires as part of the trial, in addition to those focusing on sugar.

Trial outcomes

Our primary outcomes are percentage changes in free sugar intakes and adherence to the dietary recommendations over a 12-week period. Secondary outcomes are: daily energy intake, dietary composition, anthropometry, sweet food perceptions and preferences, sweet food choice, attitudes to sweet foods, attitudes towards eating behaviour, motives for food choice, knowledge and lifestyle variables, quality of life and adverse events. Secondary qualitative outcomes are: barriers and facilitators towards intervention adherence and success / failure in achieving the recommendations. Sweet liker status, 6-n-Propylthiouracil (PROP) status, and demographic variables will also be assessed to aid in the interpretation of all outcomes.

Free sugar intakes

Change in free sugar intakes, as %TEI, will be assessed using diet diaries, undertaken using the *Nutritics software platform* and '*Libro' App* (Nutritics, 2019). Usual dietary intakes will be calculated from three days of diet diaries (1 weekend day and 2 weekdays) (National Cancer Institute, 2021) at baseline and 12 weeks.

Alongside changes in free sugar intakes, participants will also be recorded as 'successful' in achieving the dietary recommendation, where free sugar intake is ≤5%TEI, or 'not successful'

	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
Baseline	DD		DD			DD	
			Intervention provided				
Week 1	DD			DD			DD
Week 2			DD			DD	
Week 3		DD			DD		
Week 4	DD			DD			DD
Week 5				DD			
Week 6			DD				
Week 7		DD					
Week 8	DD						DD
Week 9						DD	
Week 10					DD		
Week 11				DD			
Week 12	DD		DD			DD	

where free sugar intake remains >5%TEI.

Adherence

Adherence to the dietary recommendations will also be assessed by diet diaries. Eighteen daily diet diaries, in addition to the three diaries at baseline and at 12 weeks, will be undertaken over the 12-week intervention, as identified in **Table 1**.

Table 1. Scheduled diet diary recording to measure compliance.

DD = Diet diary, including perceived adherence questions .

Adherence will be assessed from every diary, then classified five times across the 12-week intervention. During the first two weeks of the trial, adherence will be based on participant ability to reduce free sugars by ≥2%TEI from baseline or not, classified as 'adherent' or 'non-adherent' respectively. Participants will then be classified at weeks 4, 8 and 12 using data on their ability to reduce free sugars by ≥2%TEI from previous assessment (baseline for week 4), and their answers to the following adherence question: '*Are you currently following the dietary recommendations you were given?'* Reductions of free sugar intakes ≥2%TEI and an answer 'YES' will result in a classification of 'active adherent', reductions of free sugar intakes

≥2%TEI and an answer 'NO' will result in a classification of 'passive adherent', reductions of free sugar intakes <2%TEI and an answer 'NO' will result in a classification of 'active non-adherent', and reductions of free sugar intakes <2%TEI and an answer 'YES' will result in a classification of 'passive non-adherent'.

Secondary outcomes

Details for assessing all secondary outcomes, including the qualitative outcomes are given in the Supplementary Materials.

Outcome assessment schedule

An overview of the outcome assessment schedule is given in Table 2.

Table 2. Schedule of enrolment, interventions and assessments

	Trial period							
	Enrolment	Baseline		Intervention assessment				End
Time point	Wk -1 - 2	0	Intervention delivery at the end of test day 1 *	Wk 1	Wk 2	Wk 4	Wk 8	Wk 12
Enrolment								
Eligibility screen	X							
Informed consent	X							
Allocation		X						
Intervention								
Intervention groups								
Control group								
Assessments								
3 day diaries	X	X						X
24hr diet diary								
Adherence								
Adherence questions						X	X	X
Anthropometrics		X						X
Sweet liker status		X						
PROP taste test		X						
Sweet taste test		X						X
Sweet food choice		X						X
Sweet attitudes		X						X
TFEQ		X						X
FCQ		X						X
Demographics		X						
Knowledge		X						X
GSLTPAQ		X						X
SF36		X						X
Adverse events								
Difficulties / Adverse events						X	X	X

* Intervention booklet is provided to participants at the end of test day 1 in a sealed envelope, following all baseline assessments. Sweet liker status assessments based on Iatridi et al., 2019a; 2019b; PROP taste test assessments based on Bartoshuk et al., 2002; 2005; Lim et al., 2008; Sweet taste test and Sweet food choice assessments based on Appleton et al., 2022; Sweet attitudes based on Tang et al., 2021; TFEQ: Three-factor eating questionnaire (Karlsson et al., 2000); FCQ: Food choice questionnaire (Steptoe et al., 1995); GSLTPAQ: Godin-Shepard leisure time physical activity questionnaire (Godin, 2011, Godin & Shepherd, 1985); SF-36: Short-form 36 measure of quality of life (SF-36, 2021); X** Interviews completed only once; BP: Bogus pipeline method.

Free sugar intakes and adherence will be assessed throughout the intervention period as given in Table 1. All other outcomes will be assessed at baseline and at trial end, with the exception of the following: sweet liker status, PROP taste sensitivity and demographic characteristics will be measured only at baseline; questions on adherence and difficulties will be asked at weeks 4, 8 and 12.

All participants will undertake all measures, in the same manner, regardless of intervention arm. Dietary assessments, questions on adherence and difficulties will be undertaken via the Nutritics software. Self-report questionnaires will be administered online via Qualtrics. Measures associated with taste status and appetite will be presented to participants using a paper format to be completed during a test session.

Compliance with trial measures will be enhanced using a bogus pipeline method (Hugh, 2013; Muhlheim et al., 1998; Reid et al., 2014); participants will be asked to provide a saliva sample at baseline and at trial end, for the supposed purpose of examining salivary enzymes that may vary with dietary change. In reality, samples will be discarded. Only at the end of the trial will participants be informed that their samples have not been analysed.

Procedure

Trial setting

The trial is based in the United Kingdom and run from Bournemouth University. Recruitment started in April 2021 with testing commencing in May 2021. The trial will run for a total period of 18 months, over the year to ensure against seasonal effects, but we anticipate increased recruitment at certain times of the year (January - February and May – July). The trial will not continue over the Christmas period to avoid potential effects as a result of unusual dietary intakes over this period.

Recruitment and enrolment

Potential participants will be recruited via: personal contacts; University contacts and outlets, including a participant pool; contacts with local groups, e.g. church groups, adult education groups; social media advertising and flyers in local public buildings, e.g. libraries; advertising in local news outlets; flyers at local eating establishments and delivered in residential areas. The study will be marketed to participants as *'An investigation of the impacts of different dietary recommendations on diet'*.

All potential participants will be asked to complete the informed consent, eligibility form and a 3-day diet diary before being invited to participate. Eligible participants will then be scheduled for a baseline assessment, and randomised following completion of all baseline measures. The process from recruitment to enrolment is shown in Figure 1. The 3-day diet diary for eligibility will also provide an opportunity to train participants, to allow participants to gauge the commitment required for the study, and to ensure participants are competent in the diet diary data collection methods prior to their completion of baseline measures. Participants will not be recruited into the trial until they are comfortable with the commitment and diet diary data collection methods.

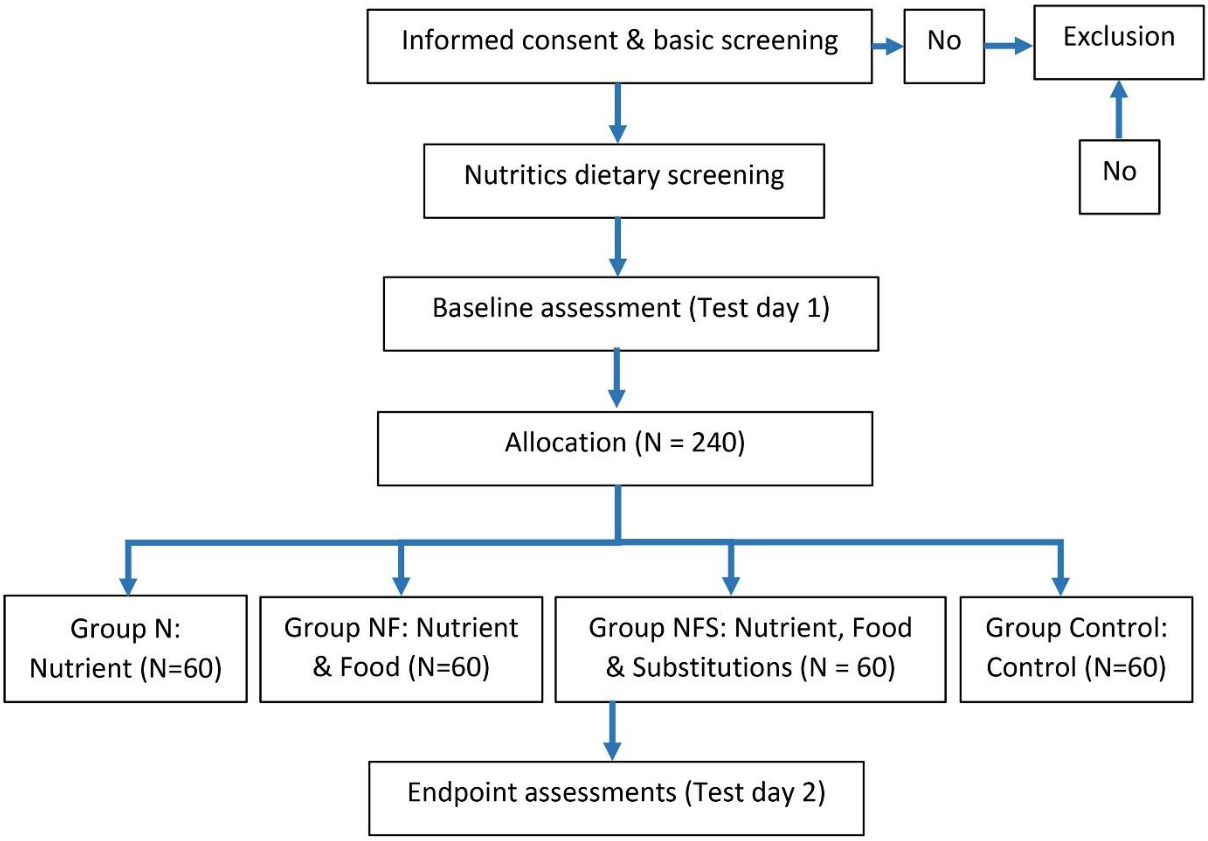

Figure 1. Participant flow diagram.

Participant testing

Baseline and end assessments will be conducted in a single session for all participants. Sessions will last approximately 30–60 min, and will be conducted at Bournemouth University where possible, or in the participant's home via Zoom. 'At-home' test sessions will be used if participants are unable or unwilling to come to the University and were intended primarily to allow the trial to continue during the COVID-19 pandemic when National lockdown measures and precautions were recommended in the UK (March 2020 - July 2021). These home test sessions may also open the trial to participants who would otherwise be unable to take part, primarily due to location, enhancing study inclusivity. Participants will be tested in the same location at both baseline and trial end, as far as possible.

All participants will complete the same measures regardless of their completion of test sessions at the University or 'at-home', with a few exceptions: Participants who are tested 'at-home' will not undertake the sweet taste perception and preference tests, the sweet food choice test, nor the solution-based measures of sweet liker status. Participants who are tested 'at-home' will also complete their own anthropometric measurements while the trial researcher observes via Zoom. Comparability across measurements will be facilitated by involvement of the same researcher whether at the University or 'at-home', and will be investigated once the trial is complete.

All sessions will commence before 11am to allow individuals to undertake the measures in a fasted state and will begin at the same time at baseline and trial end. The day before testing participants will also be asked to consume no alcohol, to consume nothing after 10pm, and to undertake no heavy exercise. Measures will be undertaken in the same order during each test session, as follows, or simply omitted: anthropometry; saliva sample; sweet liker status; PROP taste test; sweet taste test; and sweet food choice test. All participants' questionnaires will be completed and checked for completion before the test session. Incomplete questionnaires will be completed on the test day. Missing diet diaries throughout the trial will result in an automatic reminder. This reminder will ask participants to complete the diaries, but make no reference to dietary recommendations.

Withdrawal and debriefing

Participants will be considered as having withdrawn from the trial if they either request to withdraw or do not complete the final diet diaries. If individuals fail to complete diet diaries during the trial, they will be sent reminders; data will be noted as 'missing' while the participant continues in the trial.

Individuals will be debriefed on exit, or at their original 12-week intervention end time-point if other household members are partaking. During the debrief session, participants will be asked for their understanding of the trial purpose, to investigate the success of the methods to disguise the trial aims, and will then be debriefed on the true purpose of the trial. Following the debrief session, participants will be offered a consultation on their diet, by a Registered Associate Nutritionist, as a thank you for taking part.

Analyses

The data gathered will contribute to three distinct analyses: 1) Analyses of the population as a whole to investigate the effects of the three different dietary recommendations versus control; 2) Analyses of the effects of the dietary recommendations in different population subgroups, and 3) Investigation of the barriers and facilitators to success. Quantitative data will be analysed using SPSS, on an Intention-to-Treat basis, following checks for the assumptions for parametric data. Some checks for accurate diet diary recording based on Schofield equations will also be made. Exclusion of participants with missing data and high levels of likely inaccurate recording will result in the completion of additional per-protocol analyses. Qualitative data will be analysed as detailed below.

Analyses one: Effects of the different dietary recommendations

To test the effects of the different dietary recommendations, a series of multiple regression analyses will be run. A separate analysis will be run for each outcome variable, where the outcome at week 12 will be predicted by trial arm (intervention/control) and outcome variable at baseline. Additional independent variables will also be included in each analysis as possible, to include: demographic variables, total energy intakes, sweet liker status; PROP taster status; and attitudes to sweet foods, eating behaviour and food choice.

Analyses two: Effects in different population subgroups

The above analyses will be repeated in specific population groups, assuming appropriate numbers, based on demographic variables and other variables identified as important in analyses one.

Analyses three: Barriers and facilitators toward dietary change

Qualitative data will be transcribed and analysed using thematic analysis following Braun and Clarke's 6-stage methodology (Braun and Clarke, 2006). These analyses will be aided by the use of NVIVO software, and reported using the Consolidated Criteria for Reporting Qualitative Research (COREQ) (Tong et al., 2007). Themes will be gained from the population as a whole, at different time points, and interpreted in combination with the data on free sugar intakes and adherence. Comparisons will be made between those who are successful and not successful at changing their free sugar intakes, and those who are adherent and not adherent to the recommendations.

Discussion

Population estimates suggest that the majority of individuals do not achieve multiple nutrient or food-based dietary goals (Leme et al., 2021; Yau et al., 2019). Despite national public health programmes, individuals continue to overconsume nutrients, such as free sugars (Public Health England, 2020) with the health and budgetary benefits from dietary change (Public Health England, 2015) unlikely to come to fruition. This study seeks to extend the limited literature on the effectiveness of nutrient-, food-, and food-substitution-based recommendations using current PHE free sugar reducing advice. It will offer a new perspective on the effects of different dietary recommendations to enact behaviour change. The research has international relevance given widespread links between diet and disease (Roth et al., 2020) and low adherence to national dietary guidelines (Leme et al., 2021; Yau et al., 2019).

Acknowledgements

Grateful thanks are extended to the funders of this work.

Ethical approval

Ethics approval was gained from the Research Ethics Committee of Bournemouth University (Ethics ID: 30612). The standard protocol item recommendations for intervention trials (SPIRIT) guidelines (Chan et al., 2013) were used in the writing of this protocol and production of study documents.

Consent for publication

All authors approve the final manuscript. Consent for publication has been obtained from all necessary parties.

Declaration of conflicting interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: This trial is part of a PhD studentship,

funded by Bournemouth University, UK, and The International Sweeteners Association (ISA), BE.

Funding

This trial will be funded by Bournemouth University, UK, and the International Sweeteners Association (ISA), BE. The funders have offered limited comment on the trial design and materials but have had no role in the finalisation of the trial and will take no part in running the trial or interpreting the trial findings. The funders have had and will have no direct contact with the PhD student.

Funding

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Footnote

Declaration of interests This trial is part of a PhD studentship, funded by Bournemouth University, UK, and The International Sweeteners Association (ISA), BE.

Data availability statement

Materials are available from the corresponding author on request.

References

Included in published article at:

Boxall, L., Arden-Close, E., James, J., & Appleton, K. (2022). Protocol: The effects of nutrient-vs food-vs food-substitution-based dietary recommendations for reducing free sugar intakes, on free sugar intakes, dietary profiles and sweet taste outcomes: A randomised controlled trial. *Nutrition and Health*.

Appendix 2: Libro user guide provided to participants.

Nutritics Guide

How to use the Libro App

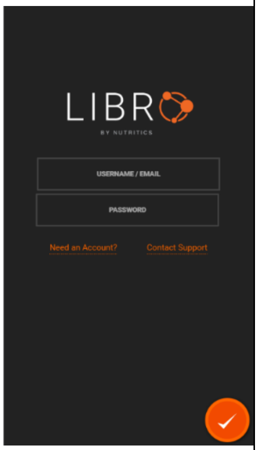
Contents

Accessing Libro

To access Libro, you will need to receive and invitation from your nutrition professional. You will be sent an email containing a link to download Libro from the Android or Apple app stores.

<u>Logging Into Libro for the First Time</u>

When you open Libro for the first time you will be presented with this screen You will need to enter a username and password to log in. The username and password you choose will be your credentials any time you log in.
Once you have entered the username and password of your choice, click the tick in the bottom of the screen to log in.



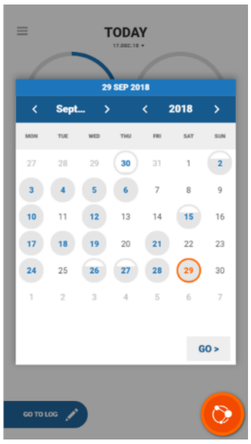
Libro Home Screen Explained

Libro has been designed to be as user friendly as possible, with a main home screen with which can be personalised with nutrition and health trackers and various displays relevant to you and your lifestyle goals. A tracker is an element of your diet or lifestyle that you wish to monitor for example, your vitamin D intake.

Your home screen is tailored to what you and your nutrition professional want you to see.

If you click on 'Today' you will access a calendar where you can search previous days.

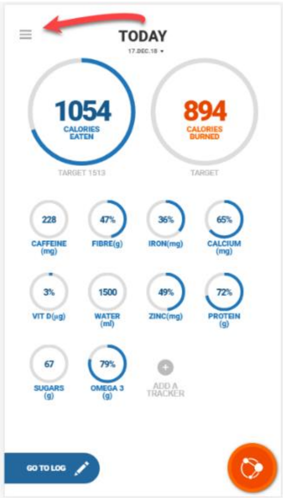
Circles filled indicates the day you have logged on Libro on that day.



Days can also be changed by swiping left and right on the home screen.

Libro Menu and Settings

The Libro Menu is available in the top right corner of the home screen.



The menu provides various support tools and account specific features such as adding and creating new foods and recipes, viewing reports and feedback shared with you, and the adding of trackers to your account

<u>TODAY</u> → This returns you to your home screen

My Food

My Food is divided into three sections – My Recipes, My Foods and Shared With Me.

My Recipes

- Any recipes created by you in Libro are stored under 'My Recipes'.
- The recipe can be viewed by selecting the 'i' icon.
- The recipe can be added to a diet log by clicking on the plus icon.

My Foods

- Any foods created by the client in Libro are stored here.
- The food can be added to a diet log by selecting the tick icon.
- The food can be viewed by selecting the 'i' icon.

Shared With Me

- Any foods or recipes shared with you from your nutrition professional are stored here.
- The food/recipe can be added to a diet log by selecting the tick icon.
- The food/recipe can be viewed by selecting the 'i' icon .

My Reports

My Reports is divided into two sections - *My Reports* and *Shared With Me*.

My Reports

- Any reports created on Libro can be viewed here.

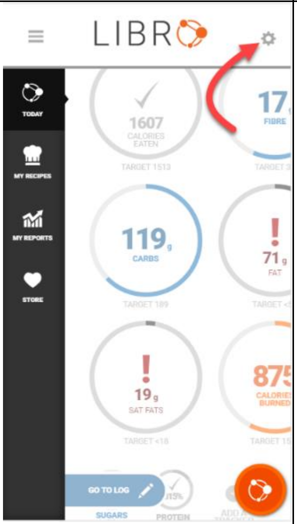
Shared With Me

- Any reports shared with you from your nutrition professional can be viewed here. To view the report, click on the report title.

Store

Add trackers to your home screen via the Libro Store.
This tracker will monitor your daily targets or intakes for each respective goal.

Settings



From the home screen you can access your settings by clicking on the menu and then the settings icon.

the 'profile' tab, you can change your personal details, specify your dietary requirements.

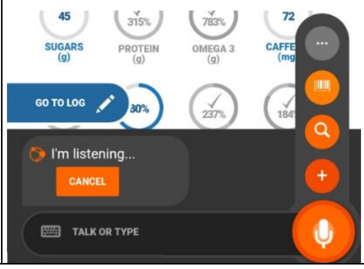
In the 'voice' tab you will see examples of questions you can ask Libro.
In the 'general' tab you can log out of Libro and change your Libro build.
We recommend you stay in the live build of Nutritics unless advised otherwise.
In the 'about' tab you can see the version of Libro you are running and log any issues you might have.

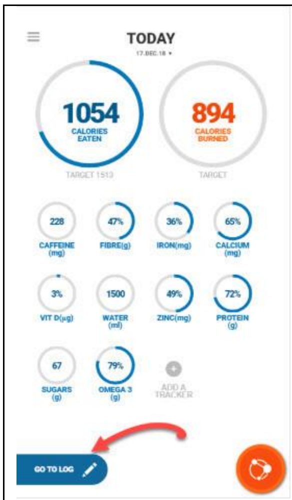
The Libro Quick Menu

You can access the Libro quick menu by clicking on the Libro icon in the bottom right corner of the screen.

This will open up the quick menu where you can easily start off a number of actions such as running a food search or creating a recipe.
Talk or type a question for Libro e.g. How much vitamin C is in an orange?
'Click on the plus icon to log a food

Click the magnifying glass to run a search
Click the barcode icon to scan a product barcode and quickly add this to your log
Click the 3 dots to open up an extended menu



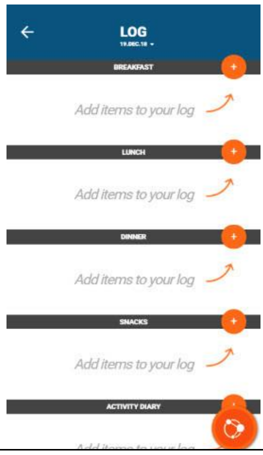


Adding Items to Your Diet Log

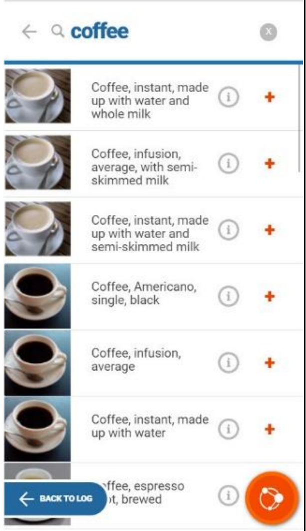
Logging Manually

1. From the homescreen, click 'Go to log'.
2. To add items to a section of the log, click on one of the orange plus buttons.
3. Enter a keyword into the search box or add from suggested foods.

Suggested foods are foods that you log frequently. For example, if you have log porridge for breakfast for a number of days, Libro will remember that you frequently have this food and suggest it the next time you log your breakfast, saving you time.



Searchable keywords include foods, recipes and exercise.

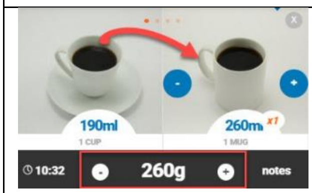


4. Click on the 'i' symbol to view more information about a food.

5. If you wish to add the food to your log, click on the 'plus' symbol.

6. Select from predetermined portion size by clicking on the portion.

Click on the plus button on the portion photo to increase the quantity by one portion. Click the minus button to decrease the quantity by half a portion. Alternatively, you can manually type a quantity in the box below the suggested portions or use Bluetooth scales to measure the exact portion weight. We have a guide on using bluetooth scales here.

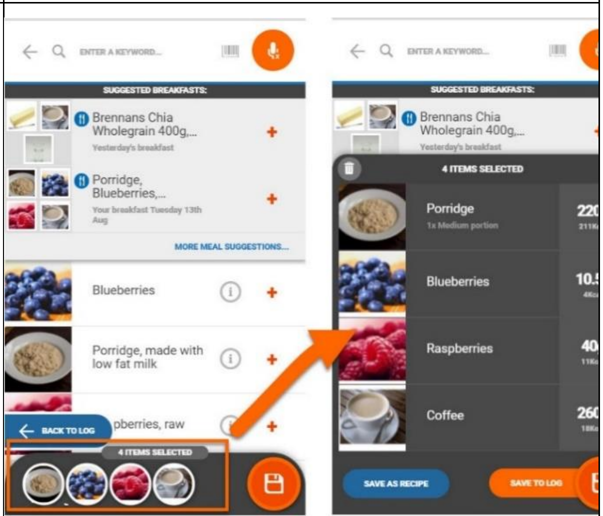


7. If you wish to increase or decrease the portion slightly, click on the plus and minus buttons either side of the portion quantity box to adjust the portion size by ± 10% of a portion.

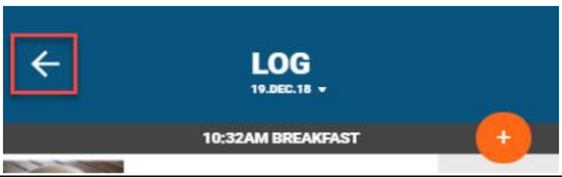
8. Click on the time to change the time of consumption or add notes by clicking on the notes button.

9. Click on the orange tick button to add the food to your basket. You can continue searching for and adding foods by following the steps above. Click on the basket to expand it.

Click on an item to edit the portion size or swipe right to delete the item from your basket. Once you are done adding foods to your basket, you can save the items as a recipe or click on the save button and the items will be added to your log.



10. Once you are finished adding foods to your log, you will be taken to your log. To see your updated nutrient trackers, click the back button again to return to the home screen.



Logging by Voice

You can add foods to your log by voice. Click icon in the bottom right corner of the screen.

You can use phrases such as '" ate an apple as a snack at 2:30pm" or "I had cornflakes with semi-skimmed milk for breakfast" and Libro will automatically add those foods to your log for you.

You will be brought to your log where you can adjust the portion size if needed.

Logging Using A Barcode

On the home screen, click on the Libro symbol in the bottom right corner of the screen and then click on the barcode symbol. Follow the prompts on screen to add the food to your log.

Alternatively:
1. On the home screen, click on 'Go to Log'.
2. Click on the orange plus button beside the name of the meal you would like to log.
3. Click on the barcode symbol to the right of the keyword search bar.
4. Scan the barcode on the food label.
5. After a food is adding from a barcode, your log will open automatically, and you can review the portion size entered.

Using Bluetooth Scales with Libro

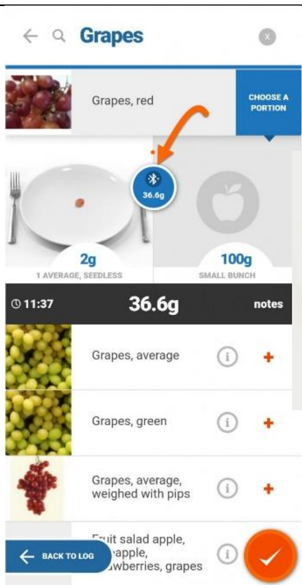
Connecting to Bluetooth Scales

Use Bluetooth weighing scales to accurately weigh your foods and recipes.
Connect Bluetooth scales to your Libro account by navigating to the menu, going to settings and clicking on the 'hardware' tab. (Image on next page)

Make sure your scales are turned on and that Bluetooth is enabled on your phone. Click 'scan for devices' and select your device from the results.

Using the Scales In Logs And Recipes

Click on the menu and then 'today' to return to the home screen. From the home screen you can use the scales to log foods and recipes to your diet log or to add a recipe to Libro.
- Create a new recipe or click 'go to log'.
- Search for the food or recipe that you want to weigh.



- Place the food item on the scales and the weight will update in Libro automatically.

- Click on the tick button to add the food to your basket. Repeat this process for any other foods you wish to add.

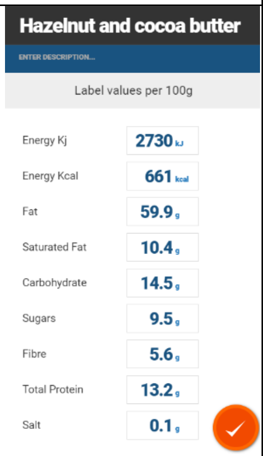
Adding a Food to Libro

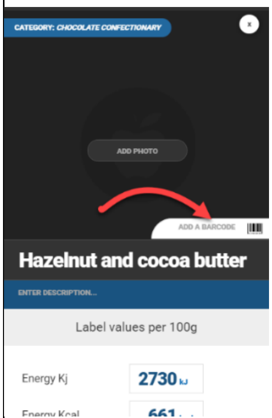
1. On the home screen, click on the menu
2. Click on 'My Food'

- Select an item from the search results - you will be prompted to select a portion size as normal, but now you will notice a Bluetooth symbol as shown below.

3. Select the ‘My foods’ tab
4. Click the ‘+New food from label’ button

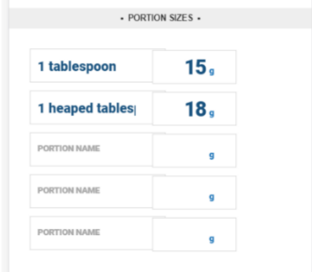
5. Give the food a name and provide a description with any additional information (for example, manufacturer, data source, flavour, searchable keywords or any other background information).
6. Add a photo from a folder or from the camera.
Fill in the label data exactly as presented on the label





(per 100g).
7. Choose a category for the food. This is important if the ingredient will be used to create recipes later on.
8. Add any allergy information detailed on the product packaging or ingredients using the allergen indicator buttons

9. Add a barcode if item is in packaging or is commercially produced.
10. Add up to 5 portion sizes.
11. Select the tick icon to save your new food



Editing Existing Items in Your Log

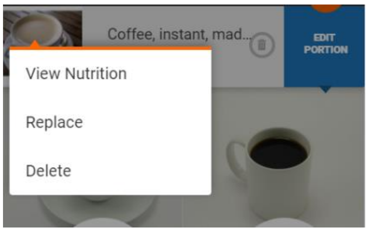
Deleting Items

From the home screen, click on ‘Go to log’. Click on the item you want to edit/delete. Click

on the ‘bin’ icon to delete the item from your log.
Alternatively, long press the item name and click on ‘delete’ or swipe right over the item name to delete it.

Replacing items

Long press on an item and click on ‘replace’ to swap it out for another item.



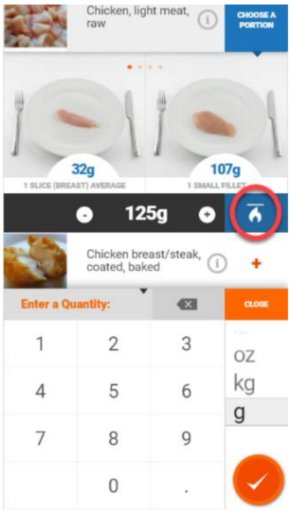
Editing portion sizes

To edit the portion size for an item in your log, open your log, click on the food/recipe you want to edit and then click on a portion size photo to select that portion, or manually edit the portion size by clicking on the portion quantity.

Adding a Recipe to Libro

1. On the home screen, click on the menu.
2.Click on ‘My Food.’
3. Select the ‘My Recipes’ tab.

4. Click the ‘+ Create a recipe’ button.
5. Enter the recipe name and description with any additional information (e.g. recipe source, web link, searchable keywords etc.)
6. Add a photo from a folder or from the camera.
7. Choose a category for your recipe by clicking the ‘category’ button above the recipe photo.
8. Click on ‘+ Add Ingredients’ to search and add ingredients.
9. Search for a food by entering a keyword into the search bar.
10. Select the orange plus button to select that ingredient and specify the quantity of the ingredient used in your recipe.
11. Click on the flame icon to the right of the ingredient



quantity to set the cooking method for that ingredient.

Cooking methods should be applied to all recipe ingredients to account for nutrient changes during the cooking process. This should only be applied if your ingredients are entered as raw (or applied to cooked ingredient where they have a second cooking method or process.

12. Click the tick icon once you have selected your ingredient quantity and cooking method.
13. Repeat steps 9-12 for each ingredient and click ‘back to recipe’ once you have added all ingredients.
14. Enter the number of portions this recipe serves.
15. You can select properties for your recipe, for example, if it’s vegetarian or gluten free.
16. Add any cooking instructions and notes for your recipe in the free text box.
17. Review the allergen information to ensure it is correct.

18. Add properties to your recipe as appropriate e.g. vegetarian or gluten free by clicking on the property’s icon.
19. Select on the orange tick to save your recipe.

Appendix 3: Dietary interventions booklets given to participants.

3.1. Recommendation page for nutrient, nutrient-and-food, nutrient-food-and-swaps interventions

<u>My Dietary Recommendation</u>

Dear Participant,

Thank you for taking part in this study,

The recording of a daily diet record will include the input of all food and drink consumed on that date using the Nutritics software.

All recording of food and drink eaten should be completed on the day you receive notification, and at the time of eating, using the Nutritics 'Libro' App.

Please see attached a guide of how to input information into your Nutritics account.
Please keep an accurate diet diary using the Nutritics software.

Your dietary recommendation is to reduce your intake of free sugars to less than 5% of your total energy intake.

Free sugars are all sugars added to foods, eg: table sugar, but does not include sugars naturally present within foods eg: fruit.

3.1 Nutrient intervention advice

<u>How to cut down on sugar in your diet</u>

We Britons really do eat too much sugar: 700g of the sweet stuff a week. That's an average of 140 teaspoons per person.

Free sugars, such as table sugar, honey and syrups, shouldn't make up more than 5% of the energy you get from food and drink each day. That's about 30g a day for anyone aged 11 and older.

Sugar's many guises

There are lots of different ways free sugar can be listed on ingredients labels:

- sucrose
- glucose
- fructose
- maltose
- fruit juice
- molasses
- hydrolysed starch
- corn syrup
- honey
- invert sugar
- agave nectar
- maple syrup
- coconut sugar

Nutrition labels tell you how much sugar a food contains:

- high in sugar – 22.5g or more of total sugar per 100g
- low in sugar – 5g or less of total sugar per 100g

Some packaging uses a colour-coded system that makes it easy to choose foods that are lower in sugar. Look for more "greens" and "ambers", and fewer "reds", in your shopping basket.

3.3. Nutrient and Food intervention advice

How to cut down on sugar in your diet

We Britons really do eat too much sugar: 700g of the sweet stuff a week. That's an average of 140 teaspoons per person.

Free sugars, such as table sugar, honey and syrups, shouldn't make up more than 5% of the energy you get from food and drink each day. That's about 30g a day for anyone aged 11 years and older.

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Some packaging uses a colour-coded system that makes it easy to choose foods that are lower in sugar. Look for more "greens" and "ambers", and fewer "reds", in your shopping basket.

Main sources of free sugar in the British diet

Sugar preserves and confectionery.

A large chunk of the free sugar in our daily diet (up to 27%) comes from table sugar, jams, chocolate, and sweets, with chocolate regularly voted Britain's favourite sweet treat.

Sweet offenders:

- chocolate spread (57.1g of total sugar per 100g)
- plain chocolate (62.6g/100g)
- fruit pastilles (59.3g/100g)

Non-alcoholic drinks

Perhaps the most surprising source, just over a fifth (21%) of the free sugar in adult diets comes from soft drinks, fruit juice and other non-alcoholic drinks.
A 500ml bottle of cola contains the equivalent of 17 cubes of sugar. Perhaps more surprising, 100% pure unsweetened fruit juice is high in the type of sugars we need to cut down on.
Sweet offenders:

- Cola (10.9g/100ml)
- Squash cordials (24.6g/100ml)

- Sweetened fruit juice (9.8g/100ml)

Biscuits, buns, and cakes

Foods such as buns, pastries, biscuits, and other cereal-based foods are often high in sugar.
Sweet offenders:

- Iced cakes (54g/100g)
- Chocolate-coated biscuits (45.8g/100g)
- Frosted corn flakes (37g/100g)

Alcoholic drinks

Some people are unaware of the sugar content in alcohol and do not include booze when calculating their daily calorie or sugar intakes.

Dairy products

Some dairy products, such as flavoured milks, yoghurts, and dairy-based desserts like ice cream, contain free sugar.
Sweet offenders:

- Fruit yoghurt (16.6g/100g)
- Fruit fromage frais (13.3g/100g)
- Choc ice (20.5g/100g)

Savoury food

Sugar is also found in surprisingly large amounts in many savoury foods, such as stir-in sauces, ketchup, salad cream, ready meals, marinades, chutneys, and crisps.

Sweet offenders:

- Tomato ketchup (27.5g/100g)
- Stir-in sweet and sour sauce (20.2g/100g)
- Salad cream (16.7g/100g)

Breakfast

Many breakfast cereals are high in sugar.
A bowl of sugary breakfast cereal could contribute 70g of sugar (up to 22 sugar cubes) to your diet over a week.

Main meals

Many foods that we don't consider to be sweet contain a surprisingly large amount of sugar. Some ready-made soups, stir-in sauces and ready meals can also be higher in sugar than you think.

A third of an average-sized jar of pasta sauce (roughly 150g) can contain more than 13g of sugar (the equivalent of 3 teaspoons of total sugars). Of this 13g, approximately ~6g may be contributed by free sugars. When eating out or buying takeaways, watch out for dishes that are typically high in sugar, such as sweet and sour dishes, sweet chilli dishes and some curry sauces, as well as salads with dressings like salad cream, which can also be high in sugar.

Condiments and sauces such as ketchup can have as much as 23g of sugar in 100g – roughly half a teaspoon per serving. These foods are usually served in small quantities, but the sugar count can add up if eaten every day.

Snacks

Dried fruit, such as raisins, dates, and apricots, is high in sugar and can be bad for your dental health because it sticks to your teeth.

To prevent tooth decay, dried fruit is best enjoyed at mealtimes – as part of a dessert, for example – rather than as a snack.

Drinks

Nearly a quarter of the free sugar in our diets comes from sugary drinks, such as fizzy drinks, sweetened juices, squashes, and cordials.

A 500ml bottle of cola contains the equivalent of 17 cubes of sugar.

Like some fizzy drinks, fruit juice can be high in sugar. When juice is extracted from the whole fruit to make fruit juice, sugar is released, and this can damage your teeth.

Your combined total of drinks from fruit juice, vegetable juice and smoothies should not be more than 150ml a day – which is a small glass. For example, if you have 150ml of orange juice and 150ml smoothie in one day, you'll have exceeded the recommendation by 150ml.

Fruit juices and smoothies do contain vitamins and minerals and can count towards your 5 A Day. However, they can only ever count as a maximum of 1 portion of your 5 A Day. For example, if you have 2 glasses of fruit juice and a smoothie in 1 day, that still only counts as 1 portion.

Dessert

Desserts are usually high in free sugar.

3.4. Nutrient, food and swap intervention advice

How to cut down on sugar in your diet

We Britons really do eat too much sugar: 700g of the sweet stuff a week. That's an average of 140 teaspoons per person.

Free sugars, such as table sugar, honey, and syrups, shouldn't make up more than 5% of the energy you get from food and drink each day. That's about 30g a day for anyone aged 11 years and older.

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There are lots of different ways free sugar can be listed on ingredients labels:

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Some packaging uses a colour-coded system that makes it easy to choose foods that are lower in sugar. Look for more "greens" and "ambers", and fewer "reds", in your shopping basket.

Main sources of free sugar in the British diet

Sugar preserves and confectionery.

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- Plain chocolate (62.6g/100g)
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Perhaps the most surprising source, just over a fifth (21%) of the free sugar in adult diets comes from soft drinks, fruit juice and other non-alcoholic drinks.

A 500ml bottle of cola contains the equivalent of 17 cubes of sugar. Perhaps more surprising, 100% pure unsweetened fruit juice is high in the type of sugars we need to cut down on.

Sweet offenders:

- Cola (10.9g/100ml)
- Squash cordials (24.6g/100ml)
- Sweetened fruit juice (9.8g/100ml)

Biscuits, buns, and cakes

Foods such as buns, pastries, biscuits, and other cereal-based foods are often high in sugar.
Sweet offenders:

- Iced cakes (54g/100g)
- Chocolate-coated biscuits (45.8g/100g)
- Frosted corn flakes (37g/100g)

Alcoholic drinks

Some people are unaware of the sugar content in alcohol and do not include booze when calculating their daily sugar intakes.

Dairy products

Some dairy products, such as flavoured milks, yoghurts and dairy-based desserts like ice cream, contain free sugar.

Sweet offenders:

- Fruit yoghurt (16.6g/100g)
- Fruit fromage frais (13.3g/100g)
- Choc ice (20.5g/100g)

Savoury food

Sugar is also found in surprisingly large amounts in many savoury foods, such as stir-in sauces, ketchup, salad cream, ready meals, marinades, chutneys, and crisps.

Sweet offenders:

- Tomato ketchup (27.5g/100g)
- Stir-in sweet and sour sauce (20.2g/100g)
- Salad cream (16.7g/100g)

Breakfast

Many breakfast cereals are high in sugar. Try switching to lower-sugar cereals or those with no free sugar, such as:

- Plain porridge
- Plain wholewheat cereal biscuits
- Plain shredded wholegrain pillows

Swapping a bowl of sugary breakfast cereal for plain cereal could cut out 70g of sugar (up to 22 sugar cubes) from your diet over a week.
If you usually add sugar to your porridge, try adding a few chopped dried apricots or a sliced or mashed banana instead.
For a more gradual approach, you could eat sugary cereals and plain cereals on alternate days or mix both in the same bowl.

If you add sugar to your cereal, you could try adding less. Or you could eat a smaller portion and add some chopped fruit, such as a pear or banana, which is an easy way of getting some of your 5 A Day.
If toast is your breakfast staple, see if you can get by with a little less of your usual spreads like jam, marmalade, honey or chocolate. Or you could try sugar-free or lower-sugar options.

Main meals

Many foods that we don't consider to be sweet contain a surprisingly large amount of sugar. Some ready-made soups, stir-in sauces and ready meals can also be higher in sugar than you think.

A third of an average-sized jar of pasta sauce (roughly 150g) can contain more than 13g of sugar (the equivalent of 3 teaspoons of total sugars). Of this 13g, approximately ~6g may be contributed by free sugars.
When eating out or buying takeaways, watch out for dishes that are typically high in sugar, such as sweet and sour dishes, sweet chilli dishes and some curry sauces, as well as salads with dressings like salad cream, which can also be high in sugar.

Condiments and sauces such as ketchup can have as much as 23g of sugar in 100g – roughly half a teaspoon per serving. These foods are usually served in small quantities, but the sugar count can add up if eaten every day.

Snacks

Dried fruit, such as raisins, dates, and apricots, is high in sugar and can be bad for your dental health because it sticks to your teeth.

To prevent tooth decay, dried fruit is best enjoyed at mealtimes – as part of a dessert, for example – rather than as a snack.

Healthier snack options are those without free sugar, such as fruit (fresh, tinned, or frozen), unsalted nuts, unsalted rice cakes, oatcakes, or homemade plain popcorn. However, dried fruit, such as raisins, dates and apricots are high in sugar.

If you're not ready to give up your favourite flavours, you could start by having less. Instead of 2 biscuits in 1 sitting, try having 1. If your snack has 2 bars, have 1 and share the other, or save it for another day.
If you're an "all-or-nothing" type person, you could find something to do to take your mind off food on some days of the week.

When shopping, look out for lower-sugar versions of your favourite snacks. Buy smaller packs or skip the family bags and just go for the normal-sized one instead.

Here are some lower-sugar substitutes for popular snacks:
- cereal bars – despite their healthy image, many cereal bars can be high in sugar. Look out for bars that are lower in sugar.
- chocolate – swap for a lower-calorie hot instant chocolate drink. You can also get chocolate with coffee and chocolate with malt varieties.
- biscuits – swap for oatcakes, oat biscuits, or unsalted rice cakes, which also provide fibre.
- cakes – swap for a plain currant bun, fruit scone, or malt loaf. If you add toppings or spreads, use them sparingly or choose lower-fat and lower-sugar varieties.

Drinks

Nearly a quarter of the free sugar in our diets comes from sugary drinks, such as fizzy drinks, sweetened juices, squashes, and cordials.

A 500ml bottle of cola contains the equivalent of 17 cubes of sugar. Try sugar-free varieties, or – better yet – water, lower-fat milk, or soda water with a splash of fruit juice.

If you take sugar in tea or coffee, gradually reduce the amount until you can cut it out altogether or try swapping to low-calorie sweetener instead. Try some new flavours with herbal teas or make your own with hot water and a slice of lemon or ginger.

Like some fizzy drinks, fruit juice can be high in sugar. When juice is extracted from the whole fruit to make fruit juice, sugar is released, and this can damage your teeth.

Your combined total of drinks from fruit juice, vegetable juice and smoothies should not be more than 150ml a day – which is a small glass. For example, if you have 150ml of orange juice and 150ml smoothie in one day, you'll have exceeded the recommendation by 150ml.

Fruit juices and smoothies do contain vitamins and minerals and can count towards your 5 A Day. However, they can only ever count as a maximum of 1 portion of your 5 A Day. For example, if you have 2 glasses of fruit juice and a smoothie in 1 day, that still only counts as 1 portion.

You could try flavouring water with a slice of lemon, lime, or a splash of fruit juice. But watch out for the sugar content in flavoured water drinks: a 500ml glass of some brands contains 15g of sugar – nearly 4 teaspoons of sugar.

Dessert

Desserts are usually high in free sugar.
Less sugary desserts include fruit – fresh, frozen, dried, or tinned, but choose those canned in juice rather than syrup – as well as lower-fat and lower-sugar rice pudding, and plain lower-fat yoghurt.

However, lower fat doesn't necessarily mean low sugar. Some lower-fat yoghurts can be sweetened with refined sugar, fruit juice concentrate, glucose, and fructose syrup.

Set some ground rules. Do you need to have dessert every day? How about only having dessert after your evening meal, or only eating dessert on odd days of the month, or only on weekends, or only at restaurants? Do you have to have chocolate, biscuits, and cake every day? If you had this type of sugary snack less often, would you actually enjoy it more?

If you're stuck between choosing 2 desserts at the supermarket, why not compare the labels on both packages and go for the 1 with the lower amount of sugar.

Information on Sweeteners

What are sweeteners?

Sweeteners are ingredients that are added to food to enhance sweetness. There are nutritive sweeteners, and those without nutritive value, ie. non-nutritive or 'low-calorie' sweeteners.

Nutritive sweeteners

There are different types of nutritive sweeteners, but they all contain carbohydrate and provide calories. They are usually referred to as 'sugars', 'added sugar' or 'free sugar'.

Polyols

Another group of nutritive sweeteners is polyols, which are sugar alcohols, and include:

- erythritol
- isomalt
- maltitol
- mannitol
- sorbitol
- xylitol.

They can be natural or artificially produced. Polyols contain carbohydrates and calories, but they have fewer calories and less of an effect on blood glucose levels than sucrose (sugar). Consuming large amounts of polyols can have a laxative effect, causing bloating, flatulence, and diarrhoea.

Non-nutritive or low-calorie sweeteners

Non-nutritive or low-calorie sweeteners can be one way of reducing your overall carbohydrate intake if you substitute them for nutritive sweeteners like sugar. These are sometimes called 'artificial sweeteners' or 'intense sweeteners'.

Low-calorie sweeteners are sweet-tasting ingredients with no, or virtually no, calories that are used to confer sweet taste to foods and drinks. As each low-calorie sweetener has specific properties, they are sometimes used in combination to achieve the required taste. Products in which low calorie sweeteners can be found include:

- 'sugar-free' or 'diet' foods and drinks
- fizzy drinks ('diet'/ 'light'/ 'zero')
- fruit juices
- jellies
- yogurts
- chewing gums, hard sweets, etc.
- tabletop sweeteners in the form of tablets, powder, or liquid.

Types of low-calorie sweeteners

There are various low-calorie sweeteners approved for use in the UK. These include:

- acesulfame potassium (acesulfame-K)
- advantame
- aspartame
- cyclamate / cyclamic acid
- neotame
- neohesperidine dihydorchalone
- saccharin
- steviol glycosides
- sucralose
- thaumatin

Using low calorie table-top sweeteners

Tabletop sweetener TABLETS

One tablet is usually formulated for sweetness intensity equivalent to one teaspoonful or one piece of sugar.

Tabletop sweetener POWDERS

A teaspoonful or sachet of a powder or granulated product usually provides sweetness intensity equivalent to one or two teaspoonfuls of sugar.

Tabletop sweetener LIQUIDS

Liquids are usually formulated to provide sweetness intensity equivalent to one teaspoonful of sugar per drop/s of liquid.

Low calorie sweeteners in UK supermarkets

Examples of table-top sweeteners that you may find in UK supermarkets include:

- Hermesetas products,
- Canderel,
- Splenda,
- Stevia,
- Sweet'n Low,
- Truvia, and many more.

These branded sweeteners are available in different forms (tablets/ mini sweeteners, powder/ granulated or liquid forms), and can be used in a variety of ways.

Sweeteners and cooking

Why use sweeteners in cooking?

They can give you a burst of sweetness, while reducing your sugar intake.

Which sweeteners are best for cooking?

Low calorie tabletop sweeteners come in powder, tablet or liquid form. Most of them can be used in cold and hot foods, but not all can be used for cooking:

- Aspartame loses some sweetness at a high temperature.
- Acesulfame-K, steviol glycosides and sucralose are heat stable and can be used in cooking and baking.

Only small amounts of low-calorie sweeteners are needed as they are intensely sweet.

Sweeteners and safety

Low calorie sweeteners, including their safety and efficacy, have gained significant attention in recent years. All low-calorie sweeteners approved to be used in foods and beverages have undergone a stringent safety assessment by food safety agencies around the world, including the European Food Safety Authority (EFSA). The safety assessment process is based on independent expert review of the collective research and only when there is strong evidence of no safety concern, a low-calorie sweetener is permitted for use as an ingredient in foods.

What amount of sweetener is safe to eat?

As part of the approval process for each low-calorie sweetener, an Acceptable Daily Intake (ADI) level is set. The ADI is the estimated amount per kilogram of body weight that a person can consume, on average, every day, over a lifetime, without risk. The responsible food safety agencies, including the European Food Safety Authority (EFSA), assess the intake of approved low-calorie sweeteners, to ensure that actual consumption of sweeteners remains within the established ADI.

Where the intake of low-calorie sweeteners may be harmful for health, medical advice will have been given – this relates only to some very specific health conditions.

Should I eat sweeteners?

It's a personal choice whether you decide to use sweeteners or not.

3.5. Dietary advice provided to the control group

My Dietary Recommendation

Dear Participant,

Thank you for taking part in this study,

The recording of a daily diet record will include the input of all food and drink consumed on that date using the Nutritics software.

All recording of food and drink eaten should be completed on the day you receive notification, and at the time of eating, using the Nutritics 'Libro' App.

Please see attached a guide of how to input information into your Nutritics account.

Please keep an accurate diet diary using the Nutritics software.

Appendix 4. Methods on collection of sweet taste perceptions and preferences.

Sweet taste perceptions and preferences were assessed using a taste test comprised of seven commonly available sweet and non-sweet foods. These were delivered in small portions to be consumed in full, in a predetermined order. Participants were asked to taste each sample and mark each food's 'pleasantness', 'desire to eat', and 'sweetness' (taste intensity) using 100mm VAS scales (Boxall et al., 2022). Current investigations into changes of dietary sweetness and their associations to sweet preferences have been inconclusive (K. M. Appleton et al., 2022). This measure was included to determine whether successful dietary change affects mealtime breakfast choices and sweet preferences after 12 weeks. This work supports the current investigations of this project's lead supervisor (K.A) and uses a similar methodology described previously (K. M. Appleton et al., 2022). These data were not analysed as part of this thesis. This test was completed on both test days after the liquid and paper tests but before the provision of breakfast.

Sweet food choice was assessed in a cold buffet-style breakfast after the rating of sweet preferences. A range of sweet and non-sweet foods suitable for consumption at breakfast was provided ad libitum, with participants free to consume as they wished. Non-sweet foods included bread or plain bagels, bran flakes, cornflakes, butter, Philadelphia cheese, peanut butter, milk, water, tea and coffee. Sweet foods included cinnamon bagels; fruit and fibre; crunchynut cornflakes; jam; honey; table sugar; sucralose, and orange juice. Items were weighed pre- and post-consumption, with all weights recorded to two decimal places. These data were not analysed as part of this thesis.

Figure 4.1: Test day in Bournemouth University food research lab

Appendix 5. Methods on height and weight taken from study standard operating procedure handbook.

5.1 Physical measurements at Bournemouth University as used by researchers.

Height

1. A free standing or wall mounted stadiometer will be used to measure participants height.
2. If a participant is unable to stand unassisted, their height will not be measured. They will be asked to self-report their height.
    a. If self-reported this must be noted by the researcher.
3. The base of the stadiometer must be wiped clean after each use, and before the first participants height is measured.
4. The researcher must wash their hands before taking physical measurements and between measurements for different participants.
5. Participants will be asked to remove heavy outer clothing and shoes, with the bottom of trousers rolled up so the base of the foot is visible.
6. The individual will be asked to stand with their feet slightly apart on the floor/base plate of the stadiometer with their heels just touching the back.
7. Participants should be asked to face forwards and stand tall with their arms relaxed at their sides.
8. The shoulders of the participants should be near to/ touching the stadiometer.
9. The participants head should be level, observed by a straight plane from the ear hole to the lower edge of the eye socket (often called the Frankfort plain, as shown in **Fig 1**.)
10. The researcher should stand to one side to complete the measurement.
11. Participants will be asked to take a deep breath and hold, while the researcher slowly brings the headplate down to just rest on the top crown of the head, pressing the hair flat.
12. The reading should now be taken at eye level, with the researcher using steps if required.
    a. The recording should be documented in cm.
13. The recording will be immediately documented by the researcher and the participant asked to step away from the stadiometer, which they should be able to complete without ducking.
14. A new participant can now be measured using the method above from step 3.

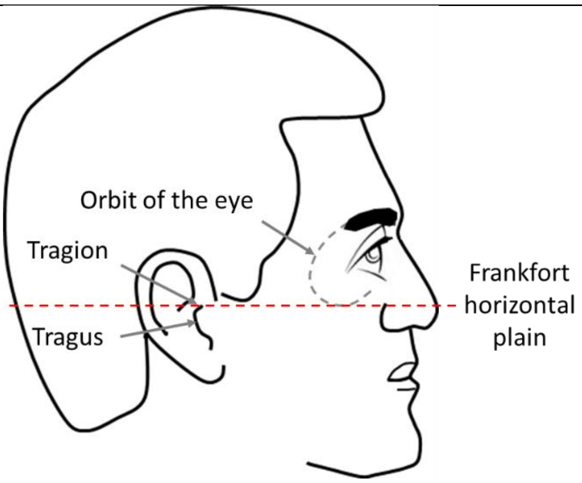

Fig 1: Frankfort horizontal plain

Weight

1. The same set of electronic scales will be used for all participants attending the BU lab version of the study, for the duration of the study.
    a. Named:
    b. The scales must be checked to ensure they are fully functioning and accurate before the first participant arrives.
    c. The scales must be placed on a flat solid surface.
2. If a participant is unable to stand unassisted, their weight will not be measured. They will be asked to self-report their weight.
    a. If weight is self-reported, this must be noted by the researcher.
3. The base of the scales must be wiped clean after each use, and before the first participants weight is measured.
4. The researcher must wash their hands before taking physical measurements and between measurements for different participants.
5. Participants will be asked to remove heavy outer clothing, shoes and empty their pockets of any objects such as mobile phones.
6. Participants will be asked to step on to the scales with their feet ~10cm apart. They will be instructed to stand still with their arms relaxed at their sides, facing straight ahead with an even posture.
    a. The researcher should check the participant is not leaning on external objects and are fully weight bearing.
7. The electronic display should now display a fixed weight (kg) which should be visible to and immediately recorded by the researcher.
8. The participant can now step of the scales and put their shoes etc back on.

Waist circumference

1. A non-stretch measuring tape should be used for recording the waist circumference.
2. The measurement should be completed over light clothing, with participants asked to remove heavy outer clothing if required.

3. The measuring tape must be wiped clean after each use, and before the first participants weight is measured.
4. The waist circumference should be measured in the midpoint between the bottom of the ribs and the top of the hip (just above belly button height).
5. The researcher will instruct the participant on how to take the measurement. Helping to maintain greater social distancing.
6. Once in place, the participant will be asked to breath in and then out while standing up straight.
7. The researcher will then visually take the waist measurement at the end point of the exhale, ensuring the tape is firm but not tight around the participants waist.
8. Measurements should be recorded in cm and immediately documented by the researcher.
9. The comparison between the waist circumference and BMI may also be documented.

5.2 Physical measurements for participants completing from Home as used by researchers.

Height

1. The recording of height measurement will be taken in the presence of the PGR via Zoom
2. The participant will be provided with a measuring tape and two labels to aid with taking their height measurement.
    a. They will be advised that having a friend or another individual on hand may aid with recording.
    b. They will require a hardback book (or flat object) and pencil.
3. If a participant is unable to stand unassisted, their height will not be measured. They will be asked to self-report their height.
    a. If self-reported this must be noted by the researcher.
4. Participants will be asked to remove heavy outer clothing and shoes, with the bottom of trousers rolled up so the base of the foot is visible via Zoom.
5. They will be asked to have a pencil and hardback book in their hands.
6. The individual will then be asked to stand with their feet slightly apart.
7. Participants should be asked to face towards the wall and stand tall.
8. The participants head should be level, observed by a straight plane from the ear hole to the lower edge of the eye socket (often called the Frankfort plain, as shown in **Fig 1**.)
9. This should be visible via Zoom.
10. Participants will be asked to place the book on the crown of their head, pressing the hair flat and then make a pencil mark on the underside of the book.
11. The participant should now measure the marked height using either their own measuring tape or the flexible measuring tape provided as a 2nd option.
12. The result will be immediately documented by the researcher and the participant asked to step away from the stadiometer.

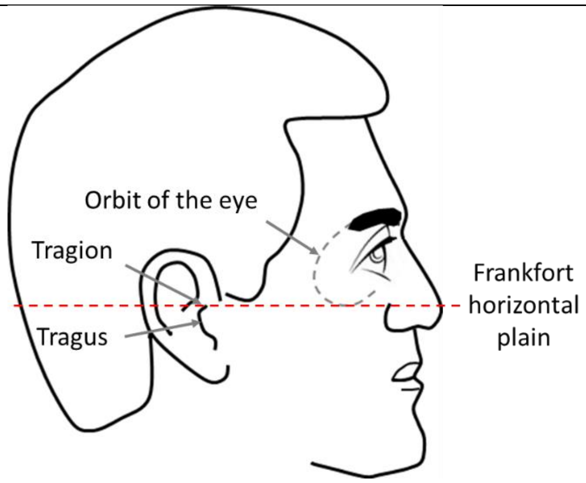

Fig 1: Frankfort horizontal plain

Weight

1. The participant will use their own set of scales for this measurement.
    a. The scales must be checked to ensure they are fully functioning and accurate before the first participant arrives.
    b. The scales must be placed on a flat solid surface.
2. If a participant is unable to stand unassisted or has a working set of scales, their weight will not be measured. They will be asked to self-report their weight.
    a. If weight is self-reported, this must be noted by the researcher. .
3. Participants will be asked to remove heavy outer clothing, shoes and empty their pockets of any objects such as mobile phones.
4. The scales should be placed on a solid, hard level floor.
5. In view of the PGR via Zoom, Participants will be asked to step on to the scales with their feet ~10cm apart. They will be instructed to stand still with their arms relaxed at their sides, facing straight ahead with an even posture.
    a. The researcher should check the participant is not leaning on external objects and are fully weight bearing.
6. The electronic display should now display a fixed weight (kg) which should be visible to and immediately recorded by the researcher.
    a. The participant may provide a picture of the display of the weight if they are unable to move their (computer/camera) to make this visible to the PGR.

Waist circumference

1. A non-stretch measuring tape should be used for recording the waist circumference.
    a. This will have been sent to participants
2. The measurement should be completed over light clothing, with participants asked to remove heavy outer clothing if required.
3. The measuring tape must be wiped clean after each use, and before the first participants weight is measured.
4. The waist circumference should be measured in the midpoint between the bottom of the ribs and the top of the hip (just above belly button height).
5. The researcher will take the measurement if consented by the participants.
6. If not the researcher will instruct the participant on how to take the measurement. Helping to maintain greater social distancing.

7. Once in place, the participant will be asked to breath in and then out while standing up straight.
8. The researcher will then visually take the waist measurement at the end point of the exhale, ensuring the tape is firm but not tight around the participants waist.
9. Measurements should be recorded in cm and immediately documented by the researcher.
10. The comparison between the waist circumference and BMI may also be documented.

Appendix 6. Baseline questionnaire form used on Qualtrics.

Start of Block: Demographics and Knowledge

Q1.1 **Welcome to the Dietary Recommendation Study!**

Your answers to the following questionnaires will be much appreciated.

Although we encourage participants to respond to all questions in one sitting, you can exit the survey at any time and recontinue where you left off at a later date, simply re-click the original link. If for some reason a questionnaire gets submitted without meaning or you want to restart, please contact lboxall@bournemouth.ac.uk or 07833352662 (Text/Whatsapp).

Q1.2 **Please complete the following demographic questions by choosing the closest answer.**

Q1.3 **Please state your Nutritics ID**
(This is the initials of your first and last name, followed by your year of birth e.g. JS1990)

____

Q1.4 **Date of birth:**

Month	▼ January ...
Day	▼ January ...
Year	▼ January ...

Q1.5 **Nationality** *(eg: British, American, Spanish etc.)*

____

Q1.6 **With what gender do you identify:**
Male
Female
Prefer not to say
Other ____

Q1.7 **Which ethnicity do you consider yourself to be:**
White (English / Welsh / Scottish / Northern Irish / British)
White (Irish)

White (Gypsy or Irish Traveller)
Any other White background

Mixed / Multiple ethnic groups (White and Black Caribbean)
Mixed / Multiple ethnic groups (White and Black African)
Mixed / Multiple ethnic groups (White and Asian)
Any other Mixed / Multiple ethnic background

Asian (Indian)
Asian (Pakistani)
Asian (Bangladeshi)
Asian (Chinese)
Any other Asian background

Black (African)
Black (Caribbean)
Any other Black / African / Caribbean background

Arab
Any other ethnic group

Q1.8 **Please indicate your occupation:**
1. Higher managerial, administrative, and professional occupations. *(Examples: Directors of major organisations; officers in armed forces; senior officers in national government; clergy; medical practitioners; higher education teaching professionals.)*
2. Lower managerial, administrative and professional occupations. *(Examples: Journalists, newspaper editors; musicians; nurses; paramedics; school, teachers).*
3. Intermediate occupations. *(Examples: Graphic designers; medical secretaries; travel agents; ambulance staff (excluding paramedics); police officers (sergeant and below)*
4. Small employers and own-account workers. *(Examples: Farmers; hotel managers; product designers; roofers; taxi-cab drivers)*
5. Lower supervisory and technical occupations. *(Examples: Bakers; electricians; gardeners; road construction operatives; train drivers)*
6. Semi-routine occupations. *(Examples: Dental nurses; farm workers; housekeepers; scaffolders; traffic wardens)*
7. Routine occupations. *(Examples: Butchers; cleaners, domestics; furniture makers; labourers in building and woodworking trades; waiters, waitresses)*
8. Never worked and long-term unemployed. *(Examples: Students, unemployed for 2 years)*

Q1.9 **Education level:**
1. Secondary school (GCSE)
2. BTEC / A levels / College level qualifications
3. Undergraduate degree
4. Postgraduate degree and above
5. Other

Q1.10 **Are you the main cook in the household:**
Yes
No

Q1.11 **Will your religion affect your dietary intake over the next 12 weeks?** *(eg: holidays of fasting)*
Yes
No

Q1.12 **Is your income level...**
Sufficient
Insufficient
Very Insufficient

Q1.13 **Which of the following best describes your diet type...**
Omnivore *(Consuming both meat and plants)*
Vegan *(Consuming only plants)*
Vegetarian *(Consuming plants and animal products such as cheese)*
Other

Q1.14 **Please list/state any UK dietary recommendations you currently know....**
____
____

End of Block: Demographics and Knowledge

Start of Block: Leisure time exercise

Q2.1 **Leisure-time exercise**
The following questionnaire will ask you to provide information about your usual leisure-time exercise habits.

1. During a typical **7-Day period (a week)**, how many times on average do you do the following kinds of **exercise for more than 15 minutes** during your free time *(write on each line the appropriate number).*

Q2.2 **Strenuous exercise (heart beats rapidly)**

(e.g., running, jogging, hockey, football, soccer, squash, basketball, cross country skiing, judo, roller skating, vigorous swimming, vigorous long-distance bicycling)
Number per week ____

Q2.3 **Moderate exercise (not exhausting)**

(e.g., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, popular and folk dancing)
Number per week ____

Q2.4 **Mild exercise (minimal effort)**

(e.g., yoga, archery, fishing from river bank, bowling, horseshoes, golf, snow-mobiling, easy walking)
Number per week ____

End of Block: Leisure time exercise

Start of Block: Food choice Steptoe

Q3.1 **Food Choice** The following questionnaire will ask you to provide information about your food choices. For the following: It is important to me that the food I eat on a typical day……
(Please tick one box for each question)

	Not at all important	A little important	Moderately important	Very important
1. Is easy to prepare	○	○	○	○
2. Contains no additives	○	○	○	○
3. Is low in calories	○	○	○	○
4. Tastes good	○	○	○	○
5. Contains natural ingredients	○	○	○	○
6. Is not expensive	○	○	○	○
7. Is low in fat	○	○	○	○

	Not at all important	A little important	Moderately important	Very important
8. Is familiar	○	○	○	○
9. Is high in fibre and roughage	○	○	○	○
10. Is nutritious	○	○	○	○
11. Is easily available in shops and supermarkets	○	○	○	○
12. Is good value for money	○	○	○	○
13. Cheers me up	○	○	○	○
14. Smells nice	○	○	○	○
15. Can be cooked very simply	○	○	○	○
16. Helps me cope with stress	○	○	○	○
17. Helps me control my weight	○	○	○	○
18. Has a pleasant texture	○	○	○	○
19. Is packaged in an environmentally friendly way	○	○	○	○
20. Comes from countries I approve of politically	○	○	○	○
21. Is like the food I ate when I was a child	○	○	○	○
22. Contains a lot of vitamins and minerals	○	○	○	○
23. Contains no artificial ingredients	○	○	○	○
24. Keeps me awake/alert	○	○	○	○
25. Looks nice	○	○	○	○
26. Helps me relax	○	○	○	○
27. Is high in protein	○	○	○	○

	Not at all important	A little important	Moderately important	Very important
28. Takes no time to prepare	○	○	○	○
29. Keeps me healthy	○	○	○	○
30. Is good for my skin/teeth/hair/nails etc	○	○	○	○
31. Makes me feel good	○	○	○	○
32. Has the country of origin clearly marked	○	○	○	○
33. Is what I usually eat	○	○	○	○
34. Helps me to cope with life	○	○	○	○
35. Can be bought in shops close to where I live or work	○	○	○	○
36. Is cheap	○	○	○	○

Q3.2 Well done you have finished 1/3 Questionnaires!

To proceed to the next, please click the arrow below, or you can exit and return to finish the remaining questions later :)

End of Block: Food choice steptoe

Start of Block: Welcome; Participant Information Sheet

Q4.1 **Sweet talk questionnaire** We want to know what you think of sweet-tasting foods, sugar, and sweeteners? Thank you for your continued interest! :-)

Q4.2 **Participant Information Sheet**
The title of the research project Sweet Talk Q: What do you think of sweet-tasting foods, sugar and sweeteners?
What is the purpose of the questionnaire? In a recent research, focus groups and interviews conducted in the United Kingdom (UK) found wide-ranging thoughts and beliefs on sweet-tasting foods, sugar and sweeteners. It is of interest to explore whether these findings apply to the wider population living in the UK. Hence, this questionnaire aims to

find out what people living in the UK, think about sweet-tasting foods, sugar and sweeteners.
Why have I been chosen? This study aims to recruit up to 600 participants from the general public of the UK. Inclusion criteria includes anyone who has been residing in the UK for at least a year and age 18 or above – both valid at the time of questionnaire administration. Exclusion criteria includes people who reside out of the UK or have only been in the UK for less than a year.
Do I have to take part? It is up to you to decide whether or not to take part. If you do decide to take part, you will have access to this information sheet to read and asked to check (✓) a box to give your consent. You can withdraw from participation at any time and without giving a reason, simply by closing the browser page. Please note that once you have completed and submitted your survey responses, we are unable to remove your anonymised responses from the study. If you or any family member have an on-going relationship with BU or the research team, e.g. as a member of staff, as student or other service user, your decision on whether to take part (or continue to take part) will not affect this relationship in any way.
How long will the online questionnaire take to complete? The questionnaire will take approximately 25 minutes to complete, and you can do it on either your laptop or mobile device. You are strongly encouraged to complete the questionnaire in one sitting, however, if you accidentally close the browser by accident, you can return back to the link on the same device and continue from where you left off.
What are the advantages and possible disadvantages or risks of taking part? Whilst there are no immediate benefits for those people participating in the project, it is hoped that this work will provide insights into developing effective strategies to improve dietary habits of the general public. Participants recruited from our participant pool will receive a summary of the results through the participant newsletter(s). In addition, anyone else interested in the research results can contact the research team (contact details below), to receive a summary of the results.
What type of information will be sought from me and why is the collection of this information relevant for achieving the research project's objectives? You will be asked to estimate your usual consumption of sweet-tasting foods, sugar and sweeteners. You will also be asked of your attitudes and opinions towards these foods, by agreeing or disagreeing with statements referring to various aspects of these foods. Several pieces of personal information will be collected from you anonymously – including gender, age, ethnicity, height, weight, education level, occupation-employment status, years residing in the UK and health conditions: whether one has intolerances or allergies to foods (especially sugar, sweetener, wheat, gluten, rice, cereal and fruits) or has any serious health condition that influences food intake and food choice. All information collected will not be linked to you at any time point. The collection of information is to better understand the demographics and lifestyle characteristics of respondents.
Use of my information Participation in this study is on the basis of consent: you do not have to complete the survey, and you can change your mind at any point before submitting the survey responses. We will use your data on the basis that it is necessary for the conduct of research, which is an activity in the public interest. We put safeguards in place to ensure that your responses are kept secure and only used as necessary for this research study and associated activities such as a research audit. Once you have submitted your survey response it will not be possible for us to remove it from the study analysis because you will

not be identifiable. The anonymous information collected may be used to support other research projects in the future and access to it in this form will not be restricted. It will not be possible for you to be identified from this data. Any published research outputs will also be anonymised, including PhD thesis, scientific papers and conferences. Bournemouth University (BU) is a Data Controller of your information which means that we are responsible for looking after your information and using it appropriately. BU's Research Participant Privacy Notice sets out more information about how we fulfil our responsibilities as a data controller and about your rights as an individual under the data protection legislation. You may read the notice here to fully understand the basis on which we will process your information.

Use and retention of identifiable information The only identifiable information collected from you will be your name and contact email or contact number for the prize draw, which is upon completion of the questionnaire. Should you feel uncomfortable with giving your information, you may choose to not participate in the prize draw. The identifiable data will only be used for said purpose only, and will be destroyed immediately upon successful contact with and delivery of prize draw to winners. Should you withdraw from the prize draw at any time point, your data will be destroyed immediately.

Contact for further information If you have any questions or would like further information, please contact Lucy Boxall, lboxall@bournemouth.ac.uk *In case of complaints* Any concerns about the study should be directed to Professor Katherine Appleton, k.appleton@bournemouth.ac.uk. If your concerns have not been answered by the research team, you should contact Professor Tiantian Zhang (Faculty of Science and Technology), Bournemouth University by email to researchgovernance@bournemouth.ac.uk.

BU Ethics ID: 32878

Q4.3 **Consent to Participate**

- ○ I confirm that I have read and understood the information provided.
- ○ I agree to take part in the study on the basis set out in the Information Sheet.

Q4.4 **Before we proceed, please answer the following questions:**

Q4.5 **Age as of 2021:**_____________

Q4.6 **Number of years residing in the UK:**____________

Q4.7 In this questionnaire, you will be asked on your intake of certain foods. You will also be asked questions on 'sweet foods' 'sugar', 'sugars' and 'sweeteners'. Please read the following definitions. **Importantly, there is a distinction between 'sugar' in singular form and 'sugarS' in plural form.** These definitions will be listed at the bottom of each page for your reference.

The term 'sweet foods' refers to all sweet-tasting foods, including fruits, sweet biscuits, cereals, spreads, confectionery, pastries, ice-cream etc, regardless of whether these are sweetened naturally, sweetened with sugar or sweetened with sweeteners. The term 'sugar' refers to "regular" table sugar, i.e. sucrose. This may take the form of sugar grain/crystal, sugar cube, sugar sachet or sugar stick. The term 'sugar**S**' refers to both 'sugar' and the sugars present in honey, syrups, unsweetened fruit juices and fruit juice concentrates. This excludes sugar from intact fruits and vegetables. The term 'sweeteners' refers to low or no calorie sweeteners that are used in place of sugar in many foods and drinks as a reduced or no calorie alternative. For example, sucralose used in Splenda, stevia leaf extract used in Truvia, aspartame used in Canderel etc. This excludes honey and syrup.

Finally, you will be asked to provide some basic information such as gender, height, weight, ethnicity etc.

Please complete the questions as honestly and as accurately as you can :-) There are no right or wrong answers - we are interested purely in your opinions!

End of Block: Welcome; Participant Information Sheet

Start of Block: Food Questions

Q5.1 The following questions ask about some foods & drinks you might have during a 'typical' week, over the past month or so. Do not be concerned if some things you eat or drink are not mentioned.

Q5.2 Please select how often you add at least one portion of **SUGAR** into the following foods / drinks: (a portion includes: one cube, one teaspoon, one sachet).

	Rarely or never	Less than 1 a Week	Once a Week	2-3 times a Week	4-6 times a Week	1-2 times a Day	3-4 times a Day	5+ a Day
Coffee	○	○	○	○	○	○	○	○
Tea	○	○	○	○	○	○	○	○
Home-cooked Dishes	○	○	○	○	○	○	○	○

Q5.3 Please select how often you add at least one portion of **HONEY** into the following foods / drinks: (a portion includes: one tablespoon, one pump/squeeze the size of your thumb).

	Rarely or never	Less than 1 a Week	Once a Week	2-3 times a Week	4-6 times a Week	1-2 times a Day	3-4 times a Day	5+ a Day
Coffee	○	○	○	○	○	○	○	○
Tea	○	○	○	○	○	○	○	○
Home-cooked Dishes	○	○	○	○	○	○	○	○

Q5.4 Please select how often you add at least one portion of **SWEETENER** into the following foods / drinks:(a portion includes: one sachet, one tablet, one teaspoon, one pump/squeeze the size of your fingertip).

	Rarely or never	Less than 1 a Week	Once a Week	2-3 times a Week	4-6 times a Week	1-2 times a Day	3-4 times a Day	5+ a Day
Coffee	○	○	○	○	○	○	○	○
Tea	○	○	○	○	○	○	○	○
Home-cooked Dishes	○	○	○	○	○	○	○	○

Q5.5 Please select how often you eat at least ONE portion of the following foods & drinks: (a portion includes: a piece of scone, a biscuit, a scoop of ice-cream, a glass of pop etc).

	Rarely or never	Less than 1 a Week	Once a Week	2-3 times a Week	4-6 times a Week	1-2 times a Day	3-4 times a Day	5+ a Day
Biscuits e.g. cereal bars, toaster pastries (Pop Tarts), gluten free biscuits.	○	○	○	○	○	○	○	○
Breakfast Cereal e.g. ready to eat cereals, granola, muesli, porridge oats.	○	○	○	○	○	○	○	○

	Rarely or never	Less than 1 a Week	Once a Week	2-3 times a Week	4-6 times a Week	1-2 times a Day	3-4 times a Day	5+ a Day
Cakes & Morning Goods e.g. cake bars and slices, American muffins, flapjacks, Swiss rolls, croissants, crumpets, English muffins, pancakes, buns, teacakes, scones, waffles, Danish pastries, fruit loaves, bagels.	○	○	○	○	○	○	○	○
Chocolate & Sweet Confectionery (**<u>not</u>** sugar free or diet) e.g. chocolate bars, filled bars, assortments, seasonal chocolate, all sweets except sugar-free sweets/ chewing gum.	○	○	○	○	○	○	○	○
Chocolate & Sweet Confectionery (sugar free or diet) e.g. carob, diabetic and low-calorie chocolate, all sugar-free sweets/ chewing gum.	○	○	○	○	○	○	○	○
Ice Cream, Lollies & Sorbets (**<u>not</u>** sugar free or diet) e.g. dairy and non-dairy, choc ices, arctic roll.	○	○	○	○	○	○	○	○
Ice Cream, Lollies & Sorbets (sugar free or diet) e.g. sugar-free or diet versions of dairy and non-dairy, choc ices, arctic roll.	○	○	○	○	○	○	○	○
Puddings e.g. canned, chilled, frozen puddings.	○	○	○	○	○	○	○	○
Sweet Spreads & Sauces e.g. confectionery branded chocolate spreads, peanut butter, flavoured peanut butter, almond butter, cashew butter, coulis, compotes, cream-based toppings, brandy sauce.	○	○	○	○	○	○	○	○
Yogurts (**<u>not</u>** sugar free or diet) e.g. sugar-sweetened dairy yogurt, fromage frais products, soya, goat sheep products except natural yogurt and unsweetened yogurt or fromage frais.	○	○	○	○	○	○	○	○

	Rarely or never	Less than 1 a Week	Once a Week	2-3 times a Week	4-6 times a Week	1-2 times a Day	3-4 times a Day	5+ a Day
Yogurts (sugar free or diet) e.g. artificially-sweetened or diet dairy yogurt, fromage frais products, soya, goat sheep products.	○	○	○	○	○	○	○	○
Fruit juice & Smoothies e.g. unsweetened fresh fruit juice, fruit concentrate, unsweetened smoothies.	○	○	○	○	○	○	○	○
Non-alcoholic fizzy drinks/pop (**not** sugar free or diet) e.g. coke, Lucozade.	○	○	○	○	○	○	○	○
Non-alcoholic fizzy drinks/pop (sugar free or diet) e.g. diet coke, diet Lemonade.	○	○	○	○	○	○	○	○

End of Block: Food Questions

Start of Block: Attitudes Questions: Sweet Foods

Q6.1 You will now answer some questions about **sweet foods**.

This refers to all sweet-tasting foods, including fruits, sweet biscuits, cereals, spreads, confectionery, pastries, ice-cream etc, regardless of whether these are sweetened naturally, sweetened with sugar or sweetened with sweeteners.

Please complete the questions as honestly and as accurately as you can :-)
There are no right or wrong answers - we are interested purely in your opinions!

Q6.2 People are too concerned about cutting down on sweet foods.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q6.3 I feel indifferent towards sweet foods.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q6.4 Sweet taste is physically addictive.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q6.5 My health or body image will determine whether I modify my sweet foods intake or not.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q6.6 Only people with obesity or diabetes need to modify their sweet foods intake.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q6.7 Desire or need for sweet foods changes with age.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q6.8 I want to reduce my intake of sweet foods.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q6.9 I tend to crave sweet foods.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q6.10 I put little or no thought into my consumption of sweet foods.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q6.11 When I consume sweet foods, I balance out my diet through exercising and/or eating other healthy foods.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q6.12 I feel guilty whenever I consume sweet foods.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q6.13 The food environment hinders me from reducing my intake of sweet foods.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q6.14 The people that I am with (family, friends, colleagues) influence my intake of sweet foods.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q6.15 Governing bodies are responsible for the influence of sweet foods on people's health.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q6.16 I am distrustful of what goes into sweet food products these days.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q6.17 I know where to find credible information on sweet foods.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q6.18 I can consume more sweet foods if they are made from sweeteners than from sugar.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q6.19 It is impossible to completely eliminate sweet foods out of my diet.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q6.20 I categorise my intake of sweet foods into “special” and “normal”.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q6.21 I only consume sweet foods during special occasions.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q6.22 The presence or absence of sweet foods in my diet influences my mood.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q6.23 I would rather be bigger in size and happy, than restrict myself and be sad.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q6.24 Drag and re-arrange the following, according to their importance to you in deciding your choice of a sweet food.
The top will be ranked as the most important, while the bottom will be ranked as the least important.
______ Cost
______ Health
______ Pleasure
______ Taste
______ Presentation

Q6.25

End of Block: Attitudes Questions: Sweet Foods

Start of Block: Attitude Questions: Sugar(s)

Q7.1 You will now answer some questions about **sugar** or **sugars**.
The term ‘sugar’ refers to <u>“regular” table sugar</u>, i.e. sucrose. This may take the form of sugar grain/crystal, sugar cube, sugar sachet or sugar stick.   The term ‘sugarS’ refers to <u>both</u> ‘sugar’ and the sugars <u>present in honey, syrups, unsweetened fruit juices and fruit juice concentrates</u>. This excludes sugar from intact fruits and vegetables.   Again, please complete the questions as honestly and as accurately as you can :-). There are no right or wrong answers - we are interested purely in your opinions!

Q7.2 People are too concerned about cutting down on sugars.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.3 I feel indifferent towards sugars.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.4 Adding sugar in food products is unnecessary.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.5 Sugar is physically addictive.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.6 Sugar is not as bad as fat for your health.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.7 Sugar is worse for your health than salt.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.8 My health or body image will determine whether I modify my sugar intake or not.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.9 Only people with obesity or diabetes need to modify their sugar intake.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.10 Desire or need for sugar changes with age.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.11 I want to reduce my intake of sugars.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.12 I tend to crave sugars.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.13 I put little or no thought into my consumption of sugars.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.14 My choice and/or consumption of sugars depends on how much knowledge I have on them.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.15 When I consume sugars, I balance out my diet through exercising and/or eating other healthy foods.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.16 I feel guilty whenever I consume sugars.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.17 The manufacturers are to blame for the amount of sugar in food these days.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.18 The food environment hinders me from reducing my intake of sugars.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.19 The people that I am with (family, friends, colleagues) influence my intake of sugars.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.20 Governing bodies are responsible for the influence of sugars on people's health.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.21 The current recommendations on sugars intake are realistic.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.22 I know where to find credible information on sugars.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.23 I am able to state what is the recommended intake of sugars.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.24 There is "good" versus "bad" sugar.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.25 Unsweetened fruit juices are healthy sources of sugars.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.26 Sugar intake increases risk for cancer.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.27 If someone asks me, “what is sugar?”, I am able to explain to him/her.

Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.28 It is impossible to completely eliminate sugar out of my diet.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.29 I only consume sugars during special occasions.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.30 The presence or absence of sugars in my diet influences my mood.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.31 All sugar is dug out from sugar mines at least 50-metres deep.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q7.32 All sugar comes from the sea.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

End of Block: Attitude Questions: Sugar(s)

Start of Block: Attitude Questions: Sweeteners

Q8.1
You will now answer some questions about sweeteners.
This refers to low or no calorie sweeteners that are used in place of sugar in many foods and drinks as a reduced or no calorie alternative. For example, sucralose used in Splenda, stevia leaf extract used in Truvia, aspartame used in Canderel etc. This excludes honey and syrup.
Once again, please complete the questions as honestly and as accurately as you can :-)
There are no right or wrong answers - we are interested purely in your opinions!

Q8.2 People are too concerned about cutting down on sweeteners.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.3 I feel indifferent towards sweeteners.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.4 Adding sweeteners in food products is unnecessary.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.5 Sweeteners are physically addictive.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.6 Sweeteners are not as bad as fat for your health.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree

Strongly disagree

Q8.7 Sweeteners are worse for your health than salt.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.8 My health or body image will determine whether I modify my sweeteners intake or not.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.9 Only people with obesity or diabetes need to modify their sweeteners intake.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.10 Desire or need for sweeteners changes with age.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.11 I want to reduce my intake of sweeteners.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.12 I tend to crave sweeteners.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.13 I put little or no thought into my consumption of sweeteners.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.14 My choice and/or consumption of sweeteners depends on how much knowledge I have on them.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.15 When I consume sweeteners, I balance out my diet through exercising and/or eating other healthy foods.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.16 I feel guilty whenever I consume sweeteners.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.17 The manufacturers are to blame for the amount of sweeteners in food these days.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.18 The food environment hinders me from reducing my intake of sweeteners.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree

Strongly disagree

Q8.19 The people that I am with (family, friends, colleagues) influence my intake of sweeteners.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.20 Governing bodies are responsible for the influence of sweeteners on people's health.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.21 I know where to find credible information on sweeteners.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.22 There are "good" versus "bad" sweeteners.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.23 Sweeteners intake increases risk for cancer.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.24 If someone asks me, “what are sweeteners?”, I am able to explain to him/her.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree

Strongly disagree

Q8.25 It is impossible to completely eliminate sweeteners out of my diet.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.26 I only consume sweeteners during special occasions.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.27 The presence or absence of sweeteners in my diet influences my mood.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.28 Labels are misleading and deceptive.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.29 I know what strategies or policies have been put in place to reduce sugar consumption in the UK.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.30 I know how to replace sugar with sweeteners in cooking and/or baking.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

Q8.31 I do not know whether to consume sugar or sweeteners.
Strongly agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Strongly disagree

End of Block: Attitude Questions: Sweeteners

Start of Block: Demographics/ Lifestyle Characteristics Questions

Q9.1
You will now answer a few questions about yourself.

Q9.2 Gender:
(We use this information to better understand the profile of our participants.)
Male
Female
Non-Binary
Prefer not to say

Q9.3 Height:
(please enter in your preferred system of measurement and put '0' in the others.)
Feet (ft) ____
Inches (in) ____
Centimetres (cm) ____

Q9.4 Weight:
(please enter in your preferred system of measurement and put '0' in the others.)
Stones (st) ____
Pounds (lb) ____
Kilograms (kg) ____

Q9.5 Are you currently suffering from any serious health condition which you feel influences your eating and food intake choice? (e.g. diabetes)
Yes (please specify) ____
No

Q9.6 Do you have intolerances or allergies to foods (especially sugar, sweetener, wheat, gluten, rice, cereal and fruits)?
Yes (please specify) ____

No

Q9.7 Are you currently following any diet program? (e.g. restricting your diet for weight loss)
Yes (please specify) ______________________________
No

Q9.8 Choose one option that best describes your ethnic group or background:
(We use this information to better understand the profile of our participants.)
(This question is developed by the GOV.UK Design System team)

English/ Welsh/ Scottish/ Northern Irish/ British
Irish
Gypsy or Irish Traveller
Any other White background, please describe
____
White and Black Caribbean
White and Black African
White and Asian
Any other Mixed/ Multiple ethnic background, please describe
____
Indian
Pakistani
Bangladeshi
Chinese
Any other Asian background, please describe
____
African
Caribbean
Any other Black/ African/ Caribbean background, please describe
____
Arab
Any other ethnic group, please describe
____
Prefer not to say

Q9.9 What is the highest degree or level of school you have completed?
(We use this information to better understand the profile of our participants.)
(This question is adapted from the Office for National Statistics)
No formal qualifications
O-Levels, GCSEs or equivalent
A-Levels, college diploma or equivalent
University degree
Post-graduate degree or higher

Vocational or other qualifications
Prefer not to say

Q9.10 Occupation:
Please tick one box to show which best describes the sort of work you do. If you are not working now, kindly tick a box to show what you did in your last job.

(We use this information to better understand the profile of our participants.)
(This question is adapted from the National Statistics Socio-economic classification (NS-SEC))

Managerial, administrative and professional occupations: teacher – nurse – physiotherapist – social worker – welfare officer – artist– musician – police officer (sergeant or above) – software designer – accountant – solicitor – medical practitioner – scientist – civil/mechanical engineer– finance manager – chief executive – office manager – retail manager – bank manager – restaurant manager – warehouse manager – publican
Intermediate occupations: non-manager or non-supervisor in secretary – personal assistant – clerical worker – office clerk – call centre agent – nursing auxiliary – nursery nurse
Small employers and own account workers: small organisations or self-employed
Lower supervisory and technical occupations: supervisor of motor mechanic – fitter – inspector – plumber – printer – tool maker – electrician – gardener – train driver – postal worker – machine operative – security guard – caretaker – farm worker – catering assistant – receptionist – sales assistant – HGV driver – van driver – cleaner – porter – packer – sewing machinist – messenger – labourer – waiter/waitress – bar staff
Semi-routine and routine occupations: non manager non supervisor as postal worker – machine operative – security guard – caretaker – farm worker – catering assistant – receptionist – sales assistant – HGV driver – van driver – cleaner – porter – packer – sewing machinist – messenger – labourer – waiter/waitress – bar staff

Q9.11 Thank you for completing this questionnaire.

Well done, you are 2/3 of the way through!

To proceed to the next please click the arrow below, or you can exit and return to finish the remaining questions later:)

End of Block: Demographics/ Lifestyle Characteristics Questions

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Start of Block: SF-36

Q10.1 **<u>This set of questions asks for your views about your health.</u>**
This information will help keep track of how you feel and how well you are able to do your usual activities. Answer every question by marking the answer as indicated. If you are unsure about how to answer a question please give the best answer you can.

Q10.2 In general, would you say your health is:
Excellent
Very Good
Good
Fair
Poor

Q10.3 Compared to one year ago, how would you rate your health in general now?
Much better than one year ago
Somewhat better now than one year ago
About the same
Somewhat worse now than one year ago
Much worse now than one year ago

Q10.4 The following questions are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?

	Yes, Limited A Lot	Yes, Limited A Little	Not Limited At All
Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports	○	○	○
Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf.	○	○	○
Lifting or carrying groceries	○	○	○
Climbing several flights of stairs	○	○	○
Climbing one flight of stairs	○	○	○
Bending, kneeling, or stooping	○	○	○
Walking more than a mile	○	○	○
Walking several blocks	○	○	○
Walking one block	○	○	○
Bathing or dressing yourself	○	○	○

Q10.5 During the **past 4 weeks**, have you had any of the following problems with your work or other regular daily activities **as a result of your physical health**?

Cut down the amount of time you spent on work or other activities?	▼ YES ... NO
Accomplished less than you would like?	▼ YES ... NO
Were limited in the kind of work or other activities?	▼ YES ... NO
Had difficulty performing the work or other activities (for example, it took extra effort)?	▼ YES ... NO

Q10.6 During the **past 4 weeks**, have you had any of the following problems with your work or other regular daily activities **as a result of any emotional problems** (such as feeling depressed or anxious)?

Cut down the amount of time you spent on work or other activities?	▼ YES ... NO
Accomplished less than you would like?	▼ YES ... NO
Didn't do work or other activities as carefully as usual?	▼ YES ... NO

Q10.7 During the **past 4 weeks**, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbours, or groups?
Not at all
Slightly
Moderately
Quite a bit
Extremely

Q10.8 How much **bodily** pain have you had during the **past 4 weeks**?
None
Very mild
Mild
Moderate
Severe
Very Severe

Q10.9 During the **past 4 weeks**, how much did **pain** interfere with your normal work (including both work outside the home and housework)?
Not at all

Slightly
Moderately
Quite a bit
Extremely

Q10.10 These questions are about how you feel and how things have been with you during the **past 4 weeks**. For each question, please give the one answer that comes closest to the way you have been feeling.
How much of the time during the **past 4 weeks**...

	All of the time	Most of the time	A good bit of the time	Some of the time	A little of the time	None of the time
Did you feel full of pep?	○	○	○	○	○	○
Have you been a very nervous person?	○	○	○	○	○	○
Have you felt so down in the dumps that nothing could cheer you up?	○	○	○	○	○	○
Have you felt calm and peaceful?	○	○	○	○	○	○
Did you have a lot of energy?	○	○	○	○	○	○
Have you felt downhearted and blue?	○	○	○	○	○	○
Did you feel worn out?	○	○	○	○	○	○
Have you been a happy person?	○	○	○	○	○	○
Did you feel tired?	○	○	○	○	○	○

Q10.11 During the **past 4 weeks**, how much of the time has **your physical health or emotional problems** interfered with your social activities (like visiting with friends, relatives, etc.)?
All of the time
Most of the time
Some of the time
A little of the time
None of the time

Q10.12 How TRUE or FALSE is **each** of the following statements for you?

	Definitely true	Mostly true	Don't know	Mostly false	Definitely false
I seem to get sick a little easier than other people	○	○	○	○	○
I am as healthy as anybody I know	○	○	○	○	○
I expect my health to get worse	○	○	○	○	○
My health is excellent	○	○	○	○	○

End of Block: SF-36

Start of Block: TFEQ

Q11.1 **This set of questions asks about your behaviour towards foods/eating**

Q11.2 1. **When I smell a delicious food, I find it very difficult to keep from eating, even if I have just finished a meal.**
Definitely true
Mostly true
Mostly false
Definitely false

Q11.3 **2. I deliberately take small helpings as a means of controlling my weight.**
Definitely true
Mostly true
Mostly false
Definitely false

Q11.4 **3. When I feel anxious, I find myself eating.**
Definitely true
Mostly true
Mostly false
Definitely false

Q11.5 **4. Sometimes when I start eating, I just can't seem to stop.**
Definitely true
Mostly true
Mostly false
Definitely false

Q11.6 **5. Being with someone who is eating often makes me hungry enough to eat also.**
Definitely true
Mostly true
Mostly false
Definitely false

Q11.7 **6. When I feel blue, I often overeat.**
Definitely true
Mostly true
Mostly false
Definitely false

Q11.8 **7. When I see a real delicacy, I often get so hungry that I have to eat right away.**
Definitely true
Mostly true
Mostly false
Definitely false

Q11.9 **8. I get so hungry that my stomach often seems like a bottomless pit.**
Definitely true
Mostly true
Mostly false
Definitely false

Q11.10 **9. I am always hungry so it is hard for me to stop eating before I finish the food on my plate.**
Definitely true
Mostly true
Mostly false
Definitely false

Q11.11 **10. When I feel lonely, I console myself by eating.**
Definitely true
Mostly true
Mostly false
Definitely false

Q11.12 **11. I consciously hold back at meals in order not to weight gain.**
Definitely true
Mostly true
Mostly false
Definitely false

Q11.13 **12. I do not eat some foods because they make me fat.**
Definitely true
Mostly true
Mostly false
Definitely false

Q11.14 **13. I am always hungry enough to eat at any time.**
Definitely true
Mostly true
Mostly false
Definitely false

Q11.15 **14. How often do you feel hungry?**
Only at meal time
Sometimes between meals
Often between meals
Almost always

Q11.16 **15. How frequently do you avoid "stocking up" on tempting foods?**
Almost never
Seldom
Moderately likely
Almost always

Q11.17 **16. How likely are you to consciously eat less than you want?**
Unlikely
Slightly likely
Moderately likely
Very likely

Q11.18 **17. Do you go on eating binges though you are not hungry?**
Never
Rarely
Sometimes
At least once a week

Q11.19 **18. On a scale of 1 to 8, where 1 means no restraint in eating (eating whatever you want, whenever you want it) and 8 means total restraint (constantly limiting food intake and never "giving in"), what number would you give yourself?**
1 2 3 4 5 6 7 8

End of Block: TFEQ

Start of Block: Pulses

Q12.1 **The following questions are designed to help us identify barriers to healthy eating**

Q12.2 **Identifying barriers to healthy eating:**
What is the purpose of the questionnaire? There are numerous varieties of Legumes (also known as "Pulses"), with common types being kidney beans, cannellini beans, fava beans, black beans, soybeans, black-eyed peas, chickpeas, and lentils (Venter et al. 2012). Legume intake remains low in many cultures, with various conflicting factors identified to be the cause. The following study aims to further understand consumption and knowledge of individuals, including the barriers they experience that prevents regular uptake of Legumes in their diet.

How long will the questionnaire/online survey take to complete? Around 15 minutes.

What are the advantages and possible disadvantages or risks of taking part? Whilst there are no immediate benefits for those people participating in the project, the information obtained may benefit the promotion of Pulses to others, with no risks involved for taking part.

What type of information will be sought from me and why is the collection of this information relevant for achieving the research project's objectives? The information obtained from the participant will be on preferences, consumption, and barriers of Legume intake. It is hoped that this research may highlight any factors that have not already been mentioned.

Contact for further information If you have any questions, would like further information, or would like a copy of this information sheet, please contact Lucy Boxall; lboxall@bournemouth.ac.uk Supervisor: Dr Katherine Appleton, k.appleton@bournemouth.ac.uk

In case of complaints Any concerns about the study should be directed firstly to Dr Katherine Appleton on k.appleton@bournemouth.ac.uk, and if they are not resolved by Katherine, should then be addressed to Deputy Dean for Research & Professional Practice, Professor Tiantian Zhang in the Faculty of Science & Technology, Bournemouth University by email to researchgovernance@bournemouth.ac.uk.

Q12.3 **Consent to Participate:** By continuing, I agree to the following statements: I have read and understood the Information Sheet and consent to take part in this questionnaire I give permission for members of the Research Team to have access to my anonymised responses. I understand that my anonymised responses may be reproduced in reports, academic publications and presentations but I will not be identified or identifiable. I understand that my data may be included in an anonymised form within a dataset which may be archived at BU's Online Research Data Repository.

If you do not consent to take part, please close your browser and do not continue further

I consent to take part in this questionnaire

Q12.4 **How often do you eat each of the following?**

(Please tick in the appropriate box. Please ensure you tick one box for every food type).

	Every day	3-5 times a week	1-2 times a week	1-2 times a fortnight	1-2 times a month	Less than once a month	Never
Baked Beans	○	○	○	○	○	○	○
Kidney, Cannellini or Borlotti Beans	○	○	○	○	○	○	○
Black, Pinto, or Butter Beans	○	○	○	○	○	○	○
Broad or Fava Beans	○	○	○	○	○	○	○
Other Beans	○	○	○	○	○	○	○
Lentils	○	○	○	○	○	○	○
Chickpeas	○	○	○	○	○	○	○
Peas	○	○	○	○	○	○	○
Peanuts	○	○	○	○	○	○	○
Milk	○	○	○	○	○	○	○
Yoghurts, Custards, Blancmanges	○	○	○	○	○	○	○
Soft Cheeses (e.g. cream cheese, Dairylea, Camenbert)	○	○	○	○	○	○	○
Hard Cheeses (e.g. Cheddar, Stilton, Emmental)	○	○	○	○	○	○	○
Nuts, other than peanuts	○	○	○	○	○	○	○
Eggs	○	○	○	○	○	○	○
Protein substitutes (e.g. Quorn)	○	○	○	○	○	○	○

Q12.5 **For the following statements, please think about Pulses** - that is beans, lentils, chickpeas and legumes, such as peas and peanuts. Tell us which option best describes the following statements.

(Please place a tick in the appropriate box. Please ensure you tick one box for every statement.)

	Strongly agree	Moderately agree	Slightly agree	Neither agree no disagree	Slightly disagree	Moderately disagree	Strongly disagree
I like pulses	○	○	○	○	○	○	○
I find pulses tasty	○	○	○	○	○	○	○
I think pulses are good for you	○	○	○	○	○	○	○
I don't eat pulses because of the texture	○	○	○	○	○	○	○
I don't eat pulses because of the smell	○	○	○	○	○	○	○
I think pulses look unappealing	○	○	○	○	○	○	○
I think pulses have a lot of flavour	○	○	○	○	○	○	○
I enjoy eating pulses	○	○	○	○	○	○	○
I am able to afford to eat pulses	○	○	○	○	○	○	○
I think eating pulses will keep me healthy	○	○	○	○	○	○	○
Pulses are difficult to eat and/or digest	○	○	○	○	○	○	○
I don't eat pulses because of	○	○	○	○	○	○	○

	Strongly agree	Moderately agree	Slightly agree	Neither agree no disagree	Slightly disagree	Moderately disagree	Strongly disagree
their appearance							
Pulses should be eaten as soon as possible after preparing them	○	○	○	○	○	○	○
Pulses to be eaten should be good quality	○	○	○	○	○	○	○
I would only eat pulses if I know where they have come from	○	○	○	○	○	○	○
I find pulses often go off quickly	○	○	○	○	○	○	○
I wouldn't prepare pulses just for me	○	○	○	○	○	○	○
I find pulses often smell unappealing	○	○	○	○	○	○	○
I find it difficult to find pulses that I like or want to eat, where I usually shop	○	○	○	○	○	○	○
Pulses are handy if I want a snack	○	○	○	○	○	○	○
I know how to prepare pulses	○	○	○	○	○	○	○
I would only eat pulses that don't show any signs of deterioration	○	○	○	○	○	○	○

	Strongly agree	Moderately agree	Slightly agree	Neither agree no disagree	Slightly disagree	Moderately disagree	Strongly disagree
I would always check on the origins of pulses before I eat them	○	○	○	○	○	○	○
I often end up wasting pulses	○	○	○	○	○	○	○
Pulses take effort to prepare and cook	○	○	○	○	○	○	○
I have always eaten pulses	○	○	○	○	○	○	○
I only eat pulses when they have been prepared or cooked for me	○	○	○	○	○	○	○
The people I eat with are willing to eat pulses	○	○	○	○	○	○	○
Pulses are quick and easy to prepare	○	○	○	○	○	○	○
I have been told not to eat pulses by doctors	○	○	○	○	○	○	○
The range of pulses where I shop is good	○	○	○	○	○	○	○
I know some good methods and/or recipes for preparing pulses	○	○	○	○	○	○	○

	Strongly agree	Moderately agree	Slightly agree	Neither agree no disagree	Slightly disagree	Moderately disagree	Strongly disagree
I don't eat pulses due to bad media	○	○	○	○	○	○	○
I'm not sure how to prepare pulses	○	○	○	○	○	○	○
The people I eat with do not eat pulses	○	○	○	○	○	○	○
I don't eat pulses for medical reasons	○	○	○	○	○	○	○
I find pulses expensive	○	○	○	○	○	○	○
I was brought up eating pulses	○	○	○	○	○	○	○
The quality of pulses is important to me	○	○	○	○	○	○	○
I eat pulses regardless of what other people tell me	○	○	○	○	○	○	○
I eat pulses only when I am cooking for or eating with other people	○	○	○	○	○	○	○
Pulses are best eaten as part of a meal	○	○	○	○	○	○	○

Q12.6 Are you male or female?

Male

Female

Non-binary / third gender

Prefer not to say

Q12.7 How old are you ?

____

Q12.8 Do you usually eat by yourself?
Eat by myself
Eat with another/others

Q12.9 Do you usually cook for yourself?
Cook for myself
Cook for another/other
I don't cook - someone else usually cooks for me

Q12.10 Thank you for participating in this study which aims to identify barriers to healthy eating.

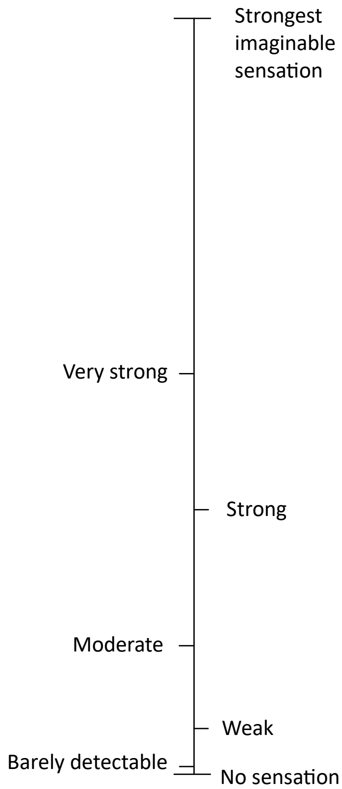
End of Block: Pulses

Appendix 7. Taste test instructions.

Example of liquid instructions provided to participants attending Bournemouth University, same methodology was adapted and used for home participants tasting paper strips.

1. Before starting the test, please rinse your mouth with the water provided, waiting 30 seconds before proceeding to the next step.
2. Next, please place all of the solution **1** in your mouth, circulating it around your mouth for 10 seconds before spitting/expectorating the solution into the glass provided.
    a. Please note the intensity of sweet taste on the line below.
    b. Please note your liking the for the taste on the 2nd line.

Please mark the intensity of the sweet taste on the line below:



Please mark your liking for the taste on the line below
<u>HOW TO MARK YOUR RESPONSES</u> Please clearly mark a vertical line through the horizontal line to indicate your response to the question. **Please mark your liking for the taste?** *Please mark the line* ______________________________ Dislike extremely   Like extremely

Appendix 8: Instructions for GLMS intensity test training.

Please read to following instructions, which provides training on using the below Intensity scale. Please contact the researcher to confirm understanding.

'You will rate the intensity of the sensations by placing a mark on the scale in front of you. The scale is partitioned by verbal descriptors of intensity that we commonly use in everyday life. As you experience a sensation, you should first determine which descriptor most appropriately describes the intensity of the sensation, then fine-tune your rating by placing a mark on the scale at the proper location between that descriptor and the next most appropriate one. Thus, if you consider a sensation is best described as moderate, but that it is toward the strong end of moderate, you should place a mark above moderate at the appropriate distance from strong. Conversely, if the sensation is on the weak side of moderate, place a mark at the appropriate location between moderate and weak. In making your judgments of intensity, you should rate the stimuli relative to other oral sensations of all kinds that you have experienced in daily life.'

Questions included:

To practise using this scale please write down the strongest sensation you have experienced to date or can possibly imagine experiencing, representing the top of the scale below.

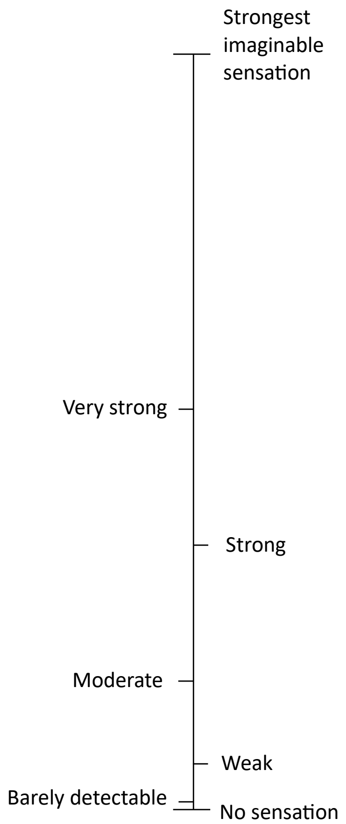
Please rate the intensity of: **The brightness of a dimly lit restaurant** *(Please mark with a line)*

*P*lease rate the intensity of: **Brightest light you have ever seen.** *(Please mark with a line)*

Please rate the intensity of: **Loudness of a whisper.** *(Please mark with a line)*

Please rate the intensity of: **Loudest sound you have ever heard.** *(Please mark with a line)*

Please rate the intensity of: **Strongest smell of a flower.** *(Please mark with a line)*



Appendix 9: Qualitative data collection methodology.

9.1 Recording strategy to ensure high quality audio recording (adapted from Poland 2001)

1. Equipment
    a. The Dictaphone used she be checked to ensure fully charged prior to the interview.
    b. The Dictaphone should be checked to ensure fully working prior to the interview.
    c. The Dictaphone should have the recording head cleaned regularly to ensure audio quality.
2. Before interview
    a. The interviewer should ensure they have a quiet and confidential space in which to conduct the interview.
    b. The recorder should be set on a stable surface.
    c. The Dictaphone should be placed close enough to the phone to ensure a high-quality audio recording.
3. During interview
    a. Speak at an average speed in a clear manner.
    b. Do not rustle papers, cups, bottles etc near the microphone.
    c. Visually check the Dictaphone is recording during the interview.
4. After interview
    a. Listen to recording – making notes and unfamiliar terminology.
    b. Label the recordings and store in the student H drive.

9.2 Telephone interview methodology

1. To arrange a telephone interview the researcher must first email the participant with three suggested dates and times for the interview.
    a. If none are suitable, the participant will be asked to provide three dates and times that are convenient for them.
2. On the interview day, two methods of audio recording will be utilised.
3. The researcher should ensure they are within a private, soundproof area to preserve data confidentiality for the duration of the interview.
4. Firstly, the call will be recorded using the app 'Tapeacall' which must be commenced prior to dialling the number provided by the participant.
5. The researcher must first ask to speak to the participant ' x name' depending on who answers the phone call.
6. When speaking to the participant they will then explain that they are ' a researcher in the dietary recommendations trial at Bournemouth University' and if the individual is available for their interview.
    a. If no, the participant will be asked if the researcher can contact them with possible future rescheduling dates via email. Begin from step 1 again.
7. If yes, the following brief outline of the interview will be explained to the participant.
    a. The interview will take a maximum of 50 minutes and you will be asked to recount your experiences following or not following the dietary

recommendations you were allocated. I personally do not need to know the recommendations as this interview is more directed at your personal experiences.

8. The participant will then be asked if they consent to being audio recorded from this moment for the purpose of this interview.
    a. If the participant does not wish to partake in the interview at this time, they will again be provided with the option to reschedule which they may answer yes or no to and they will not be audio recorded.
9. If yes, the researcher will start recording on the external voice recorder and putting the phone on speakerphone.
10. The participant will be asked to state their name and ID code and speak clearly for the audio recording.
11. The researcher will now follow the interview script as outlined from the 'Introduction' section below, using a semi-structured interview style.

9.3: Semi-Structured participant interview

Questions will be aimed at identifying each individuals' barriers and facilitators that affect their adherence to dietary recommendations.

Introduction

In general, how do you feel about dietary recommendations as a whole?

Anything positive/negative (Prompt)

Are you currently following the recommendations you were given?

Were you ever following them?

Knowledge/ behaviour/ experience

1. What was your first thought on receiving your dietary recommendation?
2. How do you feel about your progress so far?
3. Are there any elements of the recommendations in particular that you enjoy?
4. Have you found any difficulties?
5. Would anything have helped?
    - If so what? **(Prompt)**

6. Can you describe any recent changes to your eating behaviours/ habits since starting the study?
    - Changes to the types of foods you eat? **(Prompt)**
    - The number of times you eat? **(Prompt)**
    - The pleasure? **(Prompt)**
    - Taste? **(Prompt)**
7. Are there any dietary changes you would have liked to make but have been unable to?

- If yes, then why?

8. Can you describe if following the recommendations has affected your life?
    - If so how? **(Prompt)**
9. Has it affected the lives of those around you?
10. Has your view on the relationship between diet and health changed since starting the study?
11. Have the dietary recommendations affected your food/dietary knowledge?
    - If so how? **(Prompt)**
12. Can you think of anyway the recommendations may be improved?

Opinions and beliefs

13. Thinking about the guidelines you received, How achievable do you think the dietary recommendations are?
    - For yourself/individual? **(Prompt)**
    - And for the general public **(Prompt)**
14. What could be done to make achieving these goals easier?
15. Do family & friends have any influence in achieving these goals?
    - Does the government have a role? **(Prompt)**
    - The food industry? **(Prompt)**
    - Or is it all up to the individual and their free choice? **(Prompt)**

Background/demographic

16. Which (if any) factors influence your diet that are out of your control?
17. Is there anything unique to you which you think may affect your ability to achieve these dietary goals?
18. What advice would you give to others following the same recommendations?

Conclusion

19. Thank you for taking the time to participate in this interview, is there anything you would like to add before we end?

END OF INTERVIEW

Appendix 10: Participant information sheet.

Version: Dietary Recommendations – Participant Information Sheet: v2.0
Ethics ID: 30612
Date: 09/05/2021

Participant Information Sheet

The title of the research project

Dietary Recommendations

Invitation to take part

You are being invited to take part in a research project. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Who is organising/funding the research?

This research is being organised and sponsored by Bournemouth University.

What is the purpose of the project?

To date, no study has examined the direct effectiveness of different dietary advice and information on different individual diets. It is well known that dietary intake, and diet quality are linked to health status and health conditions worldwide. Although the government does analyse the dietary health of the nation through its annual 'National diet and nutrition survey' this data represents whether the nations dietary trends are changing and not whether different recommendations work for different individuals.

Therefore, if we can improve dietary intake and quality by assessing which recommendations are effective for which people at improving diet, the benefits to individuals, the community and the NHS would be widespread. By improving diet and subsequently health, we can reduce the financial burden on the NHS but also increase the quality of life for individuals across the country.

This research will help provide valuable evidence for UK nutrition governing bodies, to help guide the way information and advice is delivered. The primary aim of this study is to analyse if different dietary recommendations work to change dietary intake. This data will be viewed in light of genetic, psychological and behavioural factors as to whether different recommendations work better in different populations. It will help identify whether the recommendations work better for certain individuals or for the whole collective group.

The project will last for 12 weeks with an additional 1 week of baseline dietary data recorded before you receive your recommendations. There will be no follow up phase after the intervention, therefore, your participation will last a maximum of 13 weeks.

Why have I been chosen?

We aim to recruit 240 participants across the South of England. To be included in our study participants must be aged 18-65years, able to provide informed consent, and travel to Bournemouth University, Talbot campus or attend a Zoom meeting from home.

Potential participants may not take part if they are: pregnant/breast-feeding; underweight (BMI <18.5); have pre-existing medical conditions affecting taste and smell perception; currently following a specific dietary programme(e.g.: slimming world, the five 2 diet or Atkins); current smokers or have smoked within 3 months of the study start date; have pre-existing clinical conditions such as diabetes mellitus, eating disorders, Crohn's disease and other illnesses leading to participants receiving external nutritional advice and dietary restrictions, or have issues surrounding their ability to swallow foods and liquids.

Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a participant agreement form. We want you to understand what participation involves before you decide on whether to participate.

If you or any family member have an ongoing relationship with BU or the research team, e.g. as a member of staff, as a student or other service user, your decision on whether to take part (or continue to take part) will not affect this relationship in any way.

Can I change my mind about taking part?

Yes, you can stop participating in study activities at any time and without giving a reason.

If I change my mind, what happens to my information?

After you decide to withdraw from the study, we will not collect any further information from or about you.

As regards to the information we have already collected before this point, your rights to access, change or move that information are limited. This is because we need to manage your information in specific ways for the research to be reliable and accurate. Further explanation about this is in the Personal Information section below.

What would taking part involve?

This study involves a 3-day screening diet diary using the Nutritics software before being invited to attend the first of two test days. Test days will take place at either Bournemouth University, Talbot Campus or from home, via a Zoom meeting. All test days will take place before 11 am and last a maximum of 1.5hours, with participants asked to arrive 'fasted', e.g. having not consumed breakfast, food, or drink since the night before if attending Bournemouth University. Participants completing measures from home will be asked to attend the Zoom meeting having not consumed any food or drink before of the call.

At the first test day, participants will be asked to fill out a demographic and lifestyle questionnaire, have their height, weight, and waist circumference recorded by either a trained researcher or themselves, provide a cheek swab, sweet liker status, taste testing. Participants attending test days at Bournemouth University will also be offered breakfast, tea, and coffee. After breakfast, participants at BU will be provided with the dietary advice they will be asked to follow for the next 12-weeks. For participants completing measures from home, this will then be posted to an address of your choice.

During the next 12-weeks, all participants will be asked to record a diet diary using the 'Nutritics' computer or phone software for 21 days during the 12-week period. Participants will be asked to record dietary intakes between a minimum of once per week, to a maximum of 3 times a week. At a random point, you may also be asked to give a telephone interview. This interview will last a maximum of 1 hour, will be audio-recorded, with questions focused on your time in the study so far, as well as attitudes related to food and diet intake.

After the 12-week period, participants will be invited the attend their 2ndtest day. This will be a repeat of the first test day however, instead of being given dietary advice to follow participants will be debriefed from the study and provided with their personalized nutrition session from the Associate Nutritionist. A selection of participants may be asked to attend an additional interview on this day, with questions focused on their time during the intervention as well as attitudes related to food and diet intake. This interview will be audio-recorded. Therefore, the second test day will last 1hours (without an interview) or a maximum of 2 hours (with an interview).

There will be no follow-up after the 2nd test day.

In summary: Participants will be asked to attend 2 test days (at Bournemouth University or from home via zoom) and record diet diary information for 21 days over 12-weeks, and they may be asked to attend an additional interview. These additional interviews will be requested at random.

What are the advantages and possible disadvantages or risks of taking part?

Whilst there are no immediate benefits to you participating in the project, it is hoped that this work will provide valuable information to the governments' nutrition and public health bodies as well as the food industry in regard to dietary recommendations and product reformulations. At the end of the study participants who have completed the intervention phase will be provided with personalised nutritional information in a consultation with an Associate Nutritionist.

Whilst we do not anticipate any risks to you in taking part in this study, the test days at Bournemouth University may include multiple participants. To allow for social distancing and other COVID- 19 precautions this will be limited to a maximum of 3 participants at any one time . All physical measurements regarding body weight, height, BMI and waist circumference will be recorded in private with only the researcher carrying out the measurements. Participants should feel that they can withdraw or refuse to have any of these measurements taken and or recorded.

What type of information will be sought from me and why is the collection of this information relevant for achieving the research project's objectives?

Information regarding demographic and lifestyle factors including age, gender, nationality, ethnicity, occupation, education level, main cook in the household, income level, diet type, religion/diet impact and physical activity will be sought to control for external factors that are known to affect dietary intake and diet patterns.

Physical measurements including, BMI (from height and weight measured) and waist circumference will be measured to investigate changes from the start of the study to the study's endpoint.

Participants will be asked to undertake a taste test to identify taste preferences. These will be analysed to investigate if certain dietary patterns and recommendations can be personalised to an individual's taste preferences. Cheek/saliva swabs will be collected at the start and end of the trial and may be used to examine any differences in saliva and enzymes present in the mouth which may have been caused by dietary change. These swabs may also be analysed for genetic information and related to taste preferences at a later date if consented. The genetic information gained from cheek swabs (if consented) may be used to identify if the participant has a genetic inclination to be more sensitive to the different taste sensations of sweet, sour, bitter, salty or umami and if this, in turn, affected their intake of different foods and adherence to dietary recommendations. At the end of the study, the participant will be informed on whether their cheek/saliva samples have been analysed.

Participants will be asked to provide answers to questionnaires and potentially an interview looking at the reasons for their dietary changes or identifying barriers to achieving the changes.

Will I be recorded, and how will the recorded media be used?

The interview, if undertaken, will be recorded. The audio recordings of your activities made during this research will be used only for analysis, and the transcription of the recordings may be cited for illustration in conference presentations and lectures. No other use will be made of them, and no one outside the project will be allowed access to the original recordings. All original recordings will be deleted accordingly after transcription

How will my information be managed?

Bournemouth University (BU) is the organisation with overall responsibility for this study and the Data Controller of your personal information, which means that we are responsible for looking after your information and using it appropriately. Research is a task that we perform in the public interest, as part of our core function as a university.

Undertaking this research study involves collecting and/or generating information about you. We manage research data strictly in accordance with:

- Ethical requirements; and
- Current data protection laws. These control use of information about identifiable individuals, but do not apply to anonymous research data: "anonymous" means that we have either removed or not collected any pieces of data or links to other data which identify a specific person as the subject or source of a research result.

BU's Research Participant Privacy Notice sets out more information about how we fulfil our responsibilities as a data controller and about your rights as an individual under the data protection legislation. We ask you to read this Notice so that you can fully understand the basis on which we will process your personal information.

Research data will be used only for the purposes of the study or related uses identified in the Privacy Notice or this Information Sheet. To safeguard your rights in relation to your personal information, we will use the minimum personally identifiable information possible and control access to that data as described below.

Publication

You will not be able to be identified in any external reports or publications about the research without your specific consent. Research results will be published in peer-review journal(s) and potentially presented at conferences. Otherwise, your information will only be included in these materials in an anonymous form, i.e. you will not be identifiable.

Security and access controls

BU will hold the information we collect about you in hard copy in a secure location and on a BU password-protected secure network where held electronically.

Personal information which has not been anonymised will be accessed and used only by appropriate, authorised individuals and when this is necessary for the purposes of the research or another purpose identified in the Privacy Notice. This may include giving access to BU staff or others responsible for monitoring and/or audit of the study, who need to ensure that the research is complying with applicable regulations.

During the study, all diet diary information will be stored on the encrypted Nutritics cloud storage. Once the study has ended, all information will be downloaded from the database to the secure BU hard drives and information from the Nutritics database securely destroyed.

Further use of your information

The information collected about you may be used in an anonymous form to support other research projects in the future and access to it in this form will not be restricted. It will not be possible for you to be identified from this data.

Keeping your information if you withdraw from the study

If you withdraw from active participation in the study we will keep information which we have already collected from or about you, if this has on-going relevance or value to the study. This may include your personal identifiable information. As explained above, your legal rights to access, change, delete or move this information are limited as we need to manage your information in specific ways in order for the research to be reliable and accurate. However if you have concerns about how this will affect you personally, you can raise these with the research team when you withdraw from the study.

You can find out more about your rights in relation to your data and how to raise queries or complaints in our Privacy Notice.

Retention of research data

Project governance documentation, including copies of signed **participant agreements**: we keep this documentation for a long period after completion of the research, so that we have records of how we conducted the research and who took part. The only personal information in this documentation will be your name and signature, and we will not be able to link this to any anonymised research results.

Research results:

As described above, during the course of the study we will anonymise the information we have collected about you as an individual. This means that we will not hold your personal information in identifiable form after we have completed the research activities.

You can find more specific information about retention periods for personal information in our Privacy Notice.

We keep anonymised research data indefinitely, so that it can be used for other research as described above.

Contact for further information

If you have any questions or would like further information, please contact Lucy Boxall

Email : lboxall@bournemouth.ac.uk

Number (07833352662) (for contact about the study only):

In case of complaints

Any concerns about the study should be directed to Professor Katherine Appleton k.appleton@bournemouth.ac.uk . If your concerns have not been answered you should contact Professor TianTian Zhang, Deputy Dean Research and Professional Practice (Faculty of Science and Technology), Bournemouth University by email to researchgovernance@bournemouth.ac.uk.

Finally

If you decide to take part, you will be given a copy of the information sheet and a signed participant agreement form to keep at the study test day.

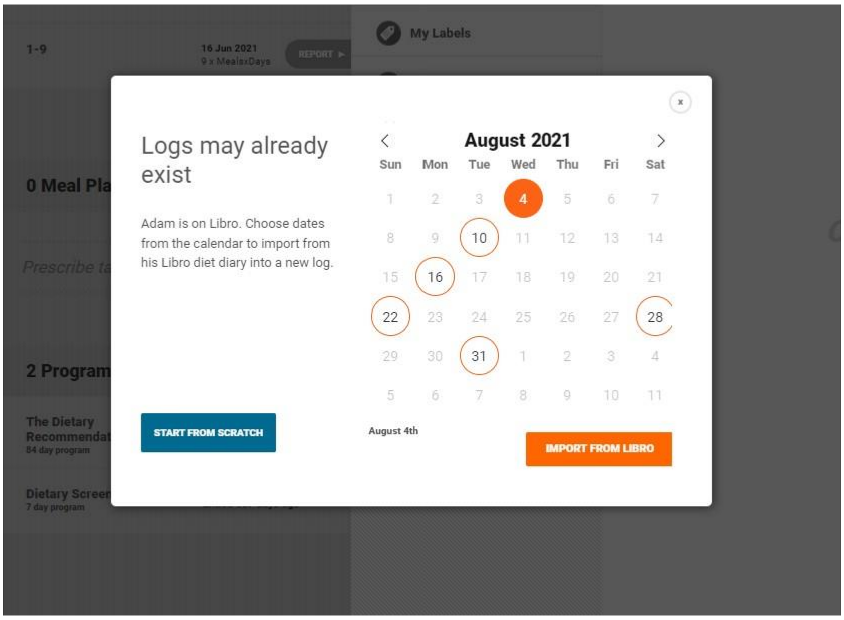
Thank you for considering taking part in this research project.

Appendix 11: Diet diary processing and data management.

Dietary data

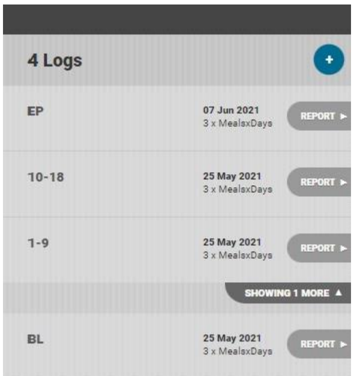
Using Nutritics diaries, separate logs for each participant were created as follows.

Diet diaries recorded on specific days as outlined in a master excel document were matched to specific dates of diet diaries as recorded by the participant. This is shown in the image below:



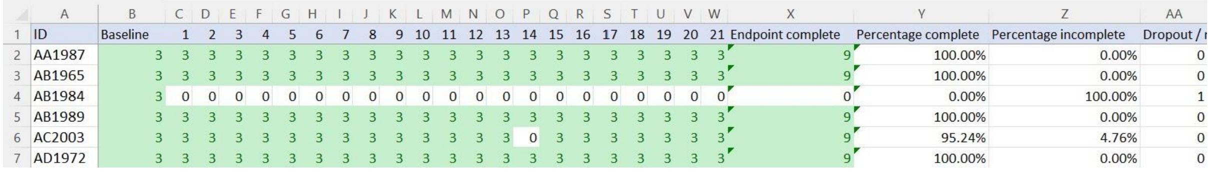
Dietary logs for analysis refer to the recording of multiple days of diet diaries generated into one report. For example a 3 day log would use diet diaries on the 4th, 10th and 16th of August 2021 as shown in the image above.

Diet diaries were sorted and named as the following for all participants before analysis:



- BL – baseline data from the 3 days of dietary screening
- 1 to 9 – Diet diaries 1-9 as recorded by the participant. If one or more days are missing there would only be 8 or less days of diaries selected. If one or more extra days were used to complete the diary, then there may be 10 or more diaries selected. (These would be adjusted as outlined **)
- 10 to 18 – As shown above but for diaries 10-18
- EP – endpoint data from the 3 days of final week on the study.

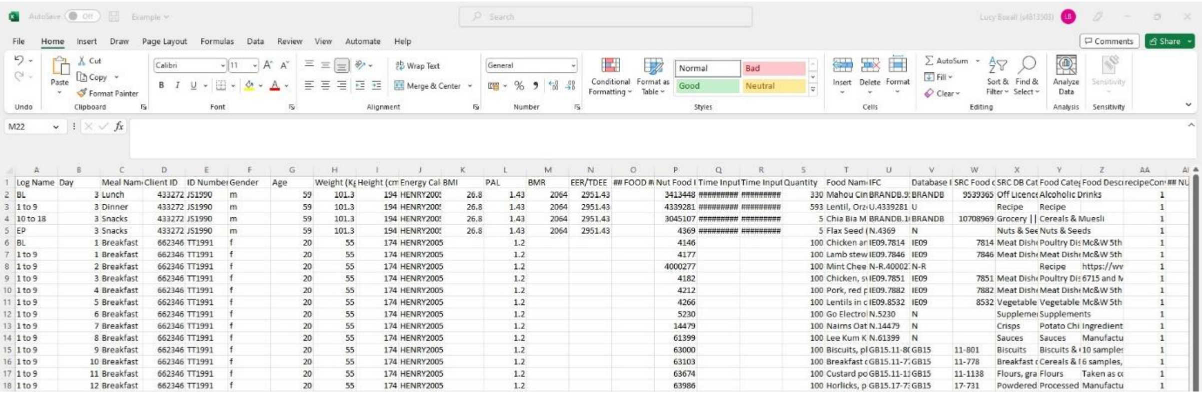
During the creation of dietary logs on nutritics for analysis. When data for specific dates was missing or extra days were used – this was simultaneously recorded in a separate excel document as shown below.



	ID	Baseline	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Endpoint complete	Percentage complete	Percentage incomplete	Dropout / r
2	AA1987	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	9	100.00%	0.00%	0
3	AB1965	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	9	100.00%	0.00%	0
4	AB1984	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00%	100.00%	1
5	AB1989	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	9	100.00%	0.00%	0
6	AC2003	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0	3	3	3	3	3	3	3	9	95.24%	4.76%	0
7	AD1972	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	9	100.00%	0.00%	0

Where data was missing 0 was input. If data for single dietary entry was recorded over multiple days, then a note (column AB not shown) was made on the participants row to adjust numbers down eg: day 9 and 10 show data for just day 9, day '10' in the nutritics document will then be adjusted down to 9.

Once all logs for each participant have been created on nutritics, they are batch exported into a CSV excel document. An example is shown below using hypothetical data.



	Log Name	Day	Meal Nam	Client ID	ID Numbe	Gender	Age	Weight (K	Height (cm	Energy Cal	BMI	PAL	BMR	EER/TDEE
2	BL	3	Lunch	433272	JS1990	m	59	101.3	194	HENRY200	26.8	1.43	2064	2951.43
3	1 to 9	3	Dinner	433272	JS1990	m	59	101.3	194	HENRY200	26.8	1.43	2064	2951.43
4	10 to 18	3	Snacks	433272	JS1990	m	59	101.3	194	HENRY200	26.8	1.43	2064	2951.43
5	EP	3	Snacks	433272	JS1990	m	59	101.3	194	HENRY200	26.8	1.43	2064	2951.43
6	BL	1	Breakfast	662346	TT1991	f	20	55	174	HENRY2005		1.2		
7	1 to 9	1	Breakfast	662346	TT1991	f	20	55	174	HENRY2005		1.2		
8	1 to 9	2	Breakfast	662346	TT1991	f	20	55	174	HENRY2005		1.2		
9	1 to 9	3	Breakfast	662346	TT1991	f	20	55	174	HENRY2005		1.2		
10	1 to 9	4	Breakfast	662346	TT1991	f	20	55	174	HENRY2005		1.2		
11	1 to 9	5	Breakfast	662346	TT1991	f	20	55	174	HENRY2005		1.2		
12	1 to 9	6	Breakfast	662346	TT1991	f	20	55	174	HENRY2005		1.2		
13	1 to 9	7	Breakfast	662346	TT1991	f	20	55	174	HENRY2005		1.2		
14	1 to 9	8	Breakfast	662346	TT1991	f	20	55	174	HENRY2005		1.2		
15	1 to 9	9	Breakfast	662346	TT1991	f	20	55	174	HENRY2005		1.2		
16	1 to 9	10	Breakfast	662346	TT1991	f	20	55	174	HENRY2005		1.2		
17	1 to 9	11	Breakfast	662346	TT1991	f	20	55	174	HENRY2005		1.2		
18	1 to 9	12	Breakfast	662346	TT1991	f	20	55	174	HENRY2005		1.2		

	## FOOD #	Nut Food I	Time Input	Time Input	Quantity	Food Nam	IFC	Database I	SRC Food c	SRC DB Cat	Food Categ	Food Desc	recipeCon	## NU
2		3413448	##########	##########	330	Mahou Cin	BRANDB.9	BRANDB	9539365	Off Licence	Alcoholic Drinks		1	
3		4339281	##########	##########	593	Lentil, Orz	U.4339281	U		Recipe	Recipe		1	
4		3045107	##########	##########	5	Chia Bia M	BRANDB.1	BRANDB	10708969	Grocery ||	Cereals & Muesli		1	
5		4369	##########	##########	5	Flax Seed (	N.4369	N		Nuts & See	Nuts & Seeds		1	
6		4146			100	Chicken ar	IE09.7814	IE09	7814	Meat Dish	Poultry Dis	Mc&W 5th	1	
7		4177			100	Lamb stew	IE09.7846	IE09	7846	Meat Dish	Meat Dish	Mc&W 5th	1	
8		4000277			100	Mint Chee	N-R.40002	N-R			Recipe	https://wv	1	
9		4182			100	Chicken, s	IE09.7851	IE09	7851	Meat Dish	Poultry Dis	6715 and N	1	
10		4212			100	Pork, red p	IE09.7882	IE09	7882	Meat Dish	Meat Dish	Mc&W 5th	1	
11		4266			100	Lentils in c	IE09.8532	IE09	8532	Vegetable	Vegetable	Mc&W 5th	1	
12		5230			100	Go Electro	N.5230	N		Suppleme	Supplements		1	
13		14479			100	Nairns Oat	N.14479	N		Crisps	Potato Chi	Ingredient	1	
14		61399			100	Lee Kum K	N.61399	N		Sauces	Sauces	Manufactu	1	
15		63000			100	Biscuits, pl	GB15.11-8	GB15	11-801	Biscuits	Biscuits &	10 samples	1	
16		63103			100	Breakfast c	GB15.11-7	GB15	11-778	Breakfast c	Cereals &	6 samples,	1	
17		63674			100	Custard po	GB15.11-1	GB15	11-1138	Flours, gra	Flours	Taken as c	1	
18		63986			100	Horlicks, p	GB15.17-7	GB15	17-731	Powdered	Processed	Manufactu	1	

Once exported log days will be in the original numerical order for each log. A backup of this data is saved as called CSV1 with no edits. A new copy file called CSV2 is then corrected using the previous spreadsheet shown in image ** which compares dates of diaries logged and whether that information has been input. Baseline diaries were corrected to days, 0.1,0.2,0.3. Diaries 1 to 9, corrected to 1,2,3,4,5,6,7,8,9 and 10 to 18 to, 10,11,12,13,14,15,16,17,18. Endpoint diaries were input as 19,20,21.

A tertiary copy of CSV1 was made in order to create a list of individual foods items logged, called CSV3. The remove duplicated function was run on all food item codes in CSV3 resulting in 10294 uniquely coded foods items. A total of 7771 items did not have information recorded for free sugars. All nutritional information for items were updated from their original quantity in grams to 100g. An example of this would be 30g of cheese logged. The nutritional values would be divided by 30 to find 1 gram and the multipled by 100 to find 100g. This was done for all individual items.

All food and drink items logged were checked individually using a variety of filters to analyse if the product was likely to contain free sugars. Filters include , text search (broccoli), food name, food category, energy kcal, carbohydrate and sugar content. Often multiple filters were used to increase the efficiency of recording, eg: search 'broccoli' and filter for lowest energy in kcal. To decide which foods needed to be recorded, example 'Sainsburys frozen broccoli' was unlikely to contain free sugars and therefore the original food code was kept with a 0 put into the free sugars column. For foods that did contain free sugars such as

‘Cadbury mini eggs’ these were recoded to another substitute food that had the full information of free sugars. The substitute coded item was selected by comparing the average of that food/drink item, and the comparative nutritional values of Kcal, Carbohydrates and sugars. For specific foods and brands, were it was unknown if the item was likely to contain free sugars, the ingredient list was researched online , using online grocery stores such as ocado, Sainsburys, Tesco’s, Asda and occasionally the brands own website. Every effort was put into retaining as many as the original food items as previously logged.

Once all items without free sugar data have been analysed to see if recoding was needed another spreadsheet, this data was input into a separate sheet within CSV2. All 67406 individual food items were updated to a 100g value using the same method as previously mentioned. Then the XLOOKUP function was utilised to identify which codes needed to replaced and those that remained the same. The delta function in a helper column was then used to compare the two columns of ‘New’ and ‘Old’ food code. All original items to be kept were then filtered and hidden in the spreadsheet. Only items which required recoding were now showing in the spreadsheet. The XLOOKUP function was again used to match code and replace all food name and nutritional values for recoded foods. Once completed the spreadsheet was copied and pasted to remove all formulas and just retain the values. All substituted and non substituted food items were then update to their original quantities. The CSV2 file was then saved for backup.

This updated data from CSV2 was copied into a new file named CSV4. In CSV4 a helper column combining the participants ID number and log day (eg: JS19900.1, combination of JS1990 and 0.1) was used in combination with a new sheet to summarise all nutrients for each participant and each diet diary day. This resulted in 5120 unique daily totals across all nutrients. The CSV4 file was then saved as complete. Including all participants and non-participants a total of 70747 individual diary entries on the study via nutritics Libro. Of this data 67546 were participant entries and 3201 screeners, with a total of 10757 unique food items logged.

Appendix 12: Methods for multiple imputation on SPSS.

Instructions for multiple imputation

1. Go to transform – random number generator. Select and set the active generator initialization at a fixed value of 950.
    a. (This step is to provide a starting point/seed for the MI to enable results to be reproduced)
2. Then Analyze – multiple imputation – impute missing data values.
    a. Variables tab
        i. Input all variables for the model in the order they are to be used (this can be found in the output document and also to summarise at the end of this doc) but is all endpoint and corresponding baseline variables, therefore excluding demographics. But including gender. (The order is central for reproducing)
        ii. Create a new data set – name ComA1_Impu
        iii. Change imputations to 20
    b. Method tab
        i. Custom – select fully conditional specification (set to 50 iterations)
        ii. Model type – change to PMM – chose from 5 closest (as is default)
    c. Constraints tab
        i. Scan data
        ii. Under define constraints – set all Endpoint variables as impute only.
            1. Instead of clicking use tab and I, plus directional keys to change this.
    d. Output tab
        i. Tick imputation model, descriptive statistics and create iteration history – name ComA1_iter
    e. Double check – click ok
3. Save the imputed and iterations files.

Sequence for multiple imputation.

BLNFS,BLDGendermale1female2,BLBMI,BLNEnergykcal,BLNCarbohydrateg,BLNProteing,BLNFatg,BLNSugarsg,BLNFreeSugarsg,BLNFibreg,BLNSaturatedFatg,BLSodiumNamg,BLWeightkg,BLWaistcircumferencecm,BLLTEShealthscore,BLFCQ1Health,BLFCQ2Mood,BLFCQ3Convenience,BLFCQ4SensoryAppeal,BLFCQ5NaturalContent,BLFC1Q6Price,BLFCQ7WeightControl,BLFCQ8Familiarity,BLFCQ19EthicalConcern,BLSQPC1Personalimpact,BLSQPC2Personalmanagement,BLSQPC3Nonchalance,BLSQPC4Negativity,BLSQPC5Perceivedunderstanding,BLSQPC6PerceivedNonautonomy,BLSF36PCS,BLSF36MCS,BLTFEQCR,BLTFEQUE,BLTFEQEE,

**Followed by imputation only variables*

Get pooled descriptives for analysis / comparison to my values.

1. Data - Split file
    a. Click split file in ComA1_imp

    b. Click compare groups
    c. By imputation number_variable
    d. Ok
2. Analyze – Descriptive statistics
    a. Descriptives
    b. Input all BL and EP variables apart from BL OG FS%.
    c. Scroll to bottom of output table for pooled means – SD will be calculated from average of 20 imputations at a later date and are not shown here.

Appendix 13: Non-significant results and tests.

Analyses two and exploratory analysis

Sweet liker

There were no significant correlations between sweet liker status, summative adherence, baseline SQ attitudes, free sugar intakes or total sugar intakes.

A chi2 test between sweet liker status and adherence timepoint 1,2,3,4 and 5 was non-significant. This test was repeated in all participants and just intervention groups.

Supertaster status

There were no significant correlations between supertaster status, summative adherence, baseline SQ attitudes, free sugar intakes or total sugar intakes.

Attitude change

Scores for change in the sweet attitudes factors 1-6 were calculated and correlated to endpoint; FS%; waist circumference; bodyweight and total energy. After Bonferroni corrections there were no significant correlations.

Sweet food counts

A one-way ANOVA was run to assess the difference between groups for baseline, timepoint 1-4 and endpoint counts for the following variables: sweetener foods, high sugar foods, medium sugar foods, low sugar foods, no sugar foods and number of items logged in both food counts and grams. There were no significant differences within or between groups for the MI or CCA dataset.

Three repeated measures analyses were run for sweetener use (percent), high sugar food items consumed (percent) and %FS intakes (3 day average) over timepoints 1-5 for both all participants and by group with no significant findings. (all participants).

Adherence summed (timepoints 1-4)

There was a significant correlation between total adherence (TP1-4) and endpoint FS%, r(240)=.-248, p<0.001.A linear regression found change in FS% was significantly predicted by summative adherence score 4 $F(2,240)=93.71$, $p<0.001$, $R^2=0.28$, R^2 adj =0.28, b=2.048 p<0.001.

BMI subgroup

To investigate whether BMI subgroup affected the intervention model 1 FS analyses were run again but separated by BMI. In repeating FS1 but separating by BMI groups the following was found:

Lean BMI: Endpoint FS% was significantly predicted, TE, $F(7,77) = 2.89$, $p = 0.02$, $R^2 = 0.21$, adj $R^2 = 0.13$ with only the baseline FS% ($b = 0.405$, $p<0.001$) variable adding significantly to the prediction.

Overweight BMI: Endpoint FS% was significantly predicted, TE, $F(7,77) = 3.02$, $p = 0.01$, $R^2 = 0.21$, adj $R^2 = 0.14$ with only the baseline FS% ($b = 0.334$, $p =0.002$) variable adding significantly to the prediction.

Obese BMI: Endpoint FS% was significantly predicted, TE, $F(7,64) = 4.20$, $p = 0.003$, $R^2 = 0.31$, adj $R^2 = 0.24$ with only the baseline FS% ($b = 0.392$, $p =0.014$) variable adding significantly to the prediction.

Appendix 14. Complete case analysis (CCA) results.

Multiple regression 1

$FS1_{All}$ (CCA)

Endpoint percentage free sugar intakes were significantly, $F(7,182)=8.47$, $p<0.001$, $R^2=0.25$, adj $R^2=0.22$, with group (b=-0.696, p=0.02), BL FS% (b=0.413, p<0.001) and BL BW (b =-0.05 , p=0.04) variables adding statistically significantly to the prediction. In completers (n=200) the mean FS% reduced in all intervention groups N, NF, NFS by 2.22%, 3.32%, 3.28% respectively, in comparison to no change in the control group -0.73%.

$BW1_{All}$ (CCA)

Endpoint bodyweight was significantly predicted, TE, $F(7,164) = 1087.35$, $p<0.001$, $R^2 = 0.98$, adj R 0.98 with BL BW (b = 0.985, p =0.001), group (b=-0.522, p=0.003), age (b=-0.033, p=0.023) and gender (b=-1.214, p=0.044) variables added statistically significantly to the prediction. In completers (n=175) the mean endpoint bodyweight reduced in all intervention groups N, NF, NFS by 0.43kg, 1.40kg, 0.82kg respectively, in comparison to no change in the control group +0.61kg.

$WC1_{All}$ (CCA)

Endpoint WC was significantly predicted, $F(7,165) = 181.40$, $p<0.001$, $R^2 = 0.89$, adj R2 0.88. Only the BL waist circumference variable (b = 0.929, p<0.001) added statistically significantly to the prediction. In completers (n=174) the mean endpoint waist circumference reduced in all intervention groups N, NF, NFS by 1.1cm, 2.9cm, 1.9cm respectively, in comparison to no change in the control group +0.06cm.

$TE1_{All}$ (CCA)

Endpoint TE was significantly predicted, $F(7,164)=8.36$, $p<0.001$, $R^2=0.26$, adj R2=0.23 with only the BL energy adding significantly (b=0.412, p<0.001) to the prediction. In completers (n=200) the mean endpoint total energy (kcal) reduced in all groups N, NF, NFS, control by 214, 317, 195 and 247 respectively.

Intervention group multiple regression CCA

A repeat of the multiple regression models in analyses one was run for only the intervention groups, N, NF and NFS.

$FS1_{IV}$ CCA

Endpoint percentage free sugar intakes were significantly predicted, $F(7,143)=5.28$, $p<0.001$, $R^2=0.21$, adj $R^2=0.17$, with only BL FS% (b=0.375, p<0.001) and endpoint total energy (b=0.002, p=0.018) added statistically significantly to the prediction.

$BW1_{IV}$ CCA

Endpoint bodyweight was significantly predicted, TE, $F(7,129) = 841.54$, $p<0.001$, $R^2 = 0.98$, adj R 0.98 with only the BL BW ($b = 0.966$, $p =0.001$) variable adding significantly to the prediction.

$WC1_{IV}$ CCA

Endpoint WC was significantly predicted, $F(7,129) = 202.20$, $p<0.001$, $R^2 = 0.92$, adj R2= 0.91. Only the BL waist circumference variable ($b =0.915$, $p =0.001$) added statistically significantly to the prediction.

TE_{IV} CCA

Endpoint TE was significantly predicted, $F(7,129)=8.79$, $p<0.001$, $R^2=0.32$, adj R2=0.29 with only the BL energy adding significantly ($b=0.468$, $p<0.001$) to the prediction.

Multiple regression 2 **(All participants)**

$FS2_{All}$ (CCA)

Endpoint percentage free sugar intakes were not significantly predicted from EP SQ PC3 nonchalance, EP SF36 MCS and EP high sugar (g) or EP high sugar (n).

$BW2_{All}$ (CCA)

Endpoint bodyweight was significantly predicted $F(10,160)=4.012$, $p<0.001$, $R^2=0.20$, R^2 adj=0.15. Only the TFEQ-EE ($b=-0.137$, $p=0.01$), SF36 PCS ($b=-0.441$, $p=0.001$) and occupation ($b=1.619$, $p=0.004$) added significantly to the prediction $p<0.001$.

$WC2_{All}$ (CCA)

Endpoint waist circumference was significantly predicted, $F(13,159)=3.882$, $p<0.001$, $R^2=0.24$, R^2 adj=0.18. Only the TFEQ-EE ($b=-0.094$, $p=0.037$), SQ PC2 ($b=4.707$, $p=0.026$), SF36 PCS ($b=-0.383$, $p<0.001$) and endpoint total knowledge ($b=-1.045$, $p=0.04$) added significantly to the prediction $p<0.001$.

$TE2_{All}$ (CCA)

Endpoint total energy was significantly predicted, $F(12,179)=2.754$, $R^2=0.13$, R^2 adj=0.09, $p=0.004$. Only the endpoint TFEQ-EE ($b=-4.327$, $p<0.001$) and endpoint FCQ 9 ($b=112.447$, $p=0.014$) added significantly to the prediction $p<0.05$.

Multiple regression three ***(All participants)***

$FS3_{All}$ (CCA)

Model one for prediction of endpoint free sugar % intakes was unchanged due to no additional significant findings in analyses 2.

$BW3_{All}$ (CCA)

Endpoint bodyweight was significantly predicted, $F(10,160)=773.035$, $p<0.001$, $R^2=0.98$, R^2 adj=0.98. Baseline BW ($b=0.974$, $p<0.001$), group ($b=-0.506$, $p=0.004$) gender ($b=-1.565$, p=0.012), age (b=-0.032, p=0.038) and EP SF36 PCS (b=-0.047, p=0.037) added significantly to the prediction.

$WC3_{All}$ (CCA)

Endpoint waist circumference was significantly predicted, $F(11,160)=116.63$, $p<0.001$, R2=0.89, R2 adj=0.88. Only the baseline WC (b=0.911, p<0.01) added significantly to the prediction p<0.001.

$TE3_{All}$ (CCA)

Endpoint total energy was significantly predicted, $F(9,161)=7.23$, $R^2=0.29$, R^2 adj=0.25, p<0.001. Only the baseline TE (b=0.393, p<0.001) added significantly to the prediction p<0.001.

Adherence tables and chi 2 (CCA)

Table 12.1

Crosstabulation of group and adherence counts across timepoints

Timepoint	Group	Adherent	Non-adherent	Participants N
TP1	Control	23(-3.5)	27(3.5)	50
	N	39(-0.1)	20(0.1)	59
	NF	45(2.3)	12(-2.3)	57
	NFS	43(1.2)	16(-1.2)	59
TP2	Control	21(-1.5)	23(1.5)	44
	N	33(-0.1)	25(0.1)	58
	NF	33(1)	19(-1)	52
	NFS	37(0.6)	24(-0.6)	61
TP3	Control	18(-2.6)	23(2.6)	41
	N	34(0.9)	17(-0.9)	51
	NF	34(0.9)	17(-0.9)	51
	NFS	36(0.7)	19(-0.7)	55
TP4	Control	18(-2.8)	22(2.8)	40
	N	33(0.3)	17(-0.3)	50
	NF	32(0.4)	16(-0.4)	48
	NFS	38(1.8)	13(-1.8)	51
TP5	Control	15(-3)	26(3)	41
	N	31(0.4)	21(-0.4)	52
	NF	35(1.5)	18(-1.5)	53
	NFS	34(1)	20(-1)	54

Footnotes: Timepoint (TP), Nutrient (N), Nutrient and food (NF), Nutrient food and substitution (NFS). Adjusted residuals shown in parentheses next to frequencies.

At timepoint one there was a significant association between group and adherence $\chi^2(3) = 14.51$, $p<0.01$. The association was moderately strong (Cohen, 1988), Cramer's V = .254. Timepoints two and three had non-significant associations between group and adherence. Timepoint four showed a significant association between group and adherence $\chi^2(3) = 8.95$, $p<0.05$. The association was moderately strong (Cohen, 1988), Cramer's V = .218. Timepoint five also showed a significant association between group and adherence $\chi^2(3) = 9.67$, $p<0.05$. The association was moderately strong (Cohen, 1988), Cramer's V = .220

Adherence (CCA) Timepoints 1-5 sum

Correlations between total adherence, endpoint; FS%; waist circumference; bodyweight and total energy was investigated. After Bonferroni corrections there was a significantly moderate correlation found between total adherence and endpoint FS%, r(162)=.-437, p<0.001.

A linear regression found change in FS% was significantly predicted by summative adherence score $F(1,165)=152.91$, $p<0.001$, $R^2=0.48$, R^2 adj =0.48, b=2.178 p<0.001.

Adherence (CCA) Timepoints 1-4 sum

There was a significant correlation between total adherence (TP1-4) and endpoint FS%, r(165)=.-325, p<0.001.

A linear regression found change in FS% was significantly predicted by summative adherence score $F(1,165)=82.89$, $p<0.001$, $R^2=0.33$, R^2 adj =0.33, b=2.172 p<0.001.

Anthropometric change CCA

A linear regression between change in BW and adherence sum TP5 was significant F(1,145)=5.16, R2=0.03, R2 adj = 0.03, b=0.277, p=0.025. A linear regression between change in WC and adherence sum TP5 was significant F (1,44)=6.66, R2=0.04 , R2 adj = 0.04, b=0.581, p=0.011

Attitude change (CCA)

Scores for change in the sweet attitudes factors 1-6 were calculated and correlated to endpoint; FS%; waist circumference; bodyweight and total energy. After Bonferroni corrections there were no significant correlations

Dietary profile (CCA)

A paired samples t-test was run to compare baseline and endpoint means for percentage intakes of, free sugars, carbohydrates, protein, fat and saturated fat. After Bonferroni corrections only free sugar percentage was significant t(199)=6.682 p<0.001, no other differences were significant.

BMI subgroup CCA

In repeating FS1 but separating by BMI groups the following was found: Although all models separated by BMI group were significant $p<0.05$. The lean BMI category differed from imputed data in that group significantly added to the prediction.

Lean BMI: Endpoint FS% was significantly predicted, TE, $F(7,62) = 3.022$, $p = 0.008$, $R^2 = 0.254$, adj $R^2 = 0.17$ with only the group ($b = -1.079$, $p = 0.044$) and baseline FS% ($b = 0.434$, $p<0.001$) variables adding significantly to the prediction.

Overweight BMI: Endpoint FS% was significantly predicted, TE, $F(7,63) = 2.847$, $p = 0.012$, $R^2 = 0.24$, adj $R^2 = 0.156$ with only the baseline FS% ($b = 0.362$, $p = 0.002$) variable adding significantly to the prediction.

Obese BMI: Endpoint FS% was significantly predicted, TE, $F(7,41) = 4.744$, $p<0.001$, $R^2 = 0.447$, adj $R^2 = 0.353$ with only the baseline FS% ($b = 0.503$, $p = 0.002$) variable adding significantly to the prediction.

Appendix 15: Codebook from qualitative analysis

NAME	DESCRIPTION
Adherence and goals	All discussions around adherence to recommendations and goals
External observed adherence or accountable	References to having shown they can adhere, awareness over their diaries being logged and taking part in the study. Aware over their intakes being monitored or observed and therefore the impact on their behaviour because of this.
Need a motivator	
Not following recommendation	States they are not following the recommendation, or references to the fact they are no longer going.
Progress adherence negativity	Feelings or emotions that are negative towards not achieving goals. Or comments around not having moved forwards in terms of certain goals
Progress adherence positivity, emotion or feeling	Positive emotion or feeling about having stuck to a recommendation, Includes positivity towards personal achievements, following the advice and achieving goals of reduction or changes
Will continue with changes	Individual states they will maintain habits or foods changes. Has taken away some aspects which they will continue on with after the end of their participation in the study
Yes following recommendation	Answer of yes or agreement that they feel they are following what they have been asked to do.
Adverts and advertising	
Advert deception	Advertising deception, only shown what gov or industry want you to see
Advertising for bad foods	References to the adverts being for bad, or unhealthy foods, or these adverts being negative
Adverts and celebs influence	Celebs endorsing food, and brands and the influence of that
Adverts and children	References to the advertising of foods or drinks being targeted towards children, or discussions that children should not be exposed to these types of adverts. Any comments regarding children’s exposure to food advertising
Adverts cause temptation	
Adverts impact mental - negative	Adverts can impact mental health, self perception,
Adverts influence	General comments regarding the influence of adverts and their general use
Healthy adverts but no impact	There are healthy adverts but they are not having an affect for whatever reason
Healthy food adverts	Taks about how healthy foods are not advertised and or should be
More control on adverts needed	General comments on more control around advertising is needed, either by the government or industry
More control food advert content	Description of more control around the content of adverts
More control food advert timing	Comments over the control of food advert timing.
Not exposed or influence on adverts	Individual feels they are not exposed or influenced by adverts
Removal of adverts helps temptation	No being exposed to adverts would be better for diet or the individual health
Awareness, mindful, thoughts	
Awareness of other's diets	Increased awareness on the food intake of other individuals.

NAME	DESCRIPTION
Awareness over nutrient and ingredients in items consumed	Comments over an increased awareness of the ingredients within foods, such as from labels and ingredient lists
Food awareness	Discussions around the awareness of foods and how that leads into the selection of food and drink items.
Food intake awareness	Conscious thoughts or awareness on the amount consumed and when. More direct references to the intake of food and drink.
Increased public awareness	Discussions around the need to make the public more awareness of diet, health and dietary recommendations.
More mindful of health and diet links.	Descriptions of being more aware and mindful of the connection between health and diet.
Overall healthy diet and food choice awareness (holistic)	Thinking about healthy food choices, and having a more balanced diet, making choices from that point of view. Also references a holistic view of the diet, and awareness over having a healthy or unhealthy eating day or week
Sugar intake not known (difficult) unclear on recommendations low awareness	Not knowing the amount of sugar in foods and the amount they are consuming. Also discussions around not knowing their baseline intakes.
Thinking about foods more mindful now	Generalised thinking about foods and the selection of them.
Barriers to change	
Barrier being forgetful	Being forgetful or not mindful of eating
Barrier to change (attitudes or mentality)	General comments about attitude and perceptions that are barriers to healthy eating or dietary change. This can include previous habits or thoughts on the recommendation.
Barrier - feeling cannot achieve recommendation	For whatever reason is stated they feel they cannot achieve the recommendation, and this was a limiting factor
Barrier apathy or disinterest	Not interested in diet or dietary change, can't be bothered sometimes
Barrier changing your mindset	Changing your mindset is a barrier to better eating or habits
Barrier general mindset	
Barrier going too far	
Barrier making excuses	Making excuses as why you cannot change
Barrier mindset from upbringing or family	Family and upbringing and therefore the relationship with food and dietary habits are a barrier to better eating and dietary change
Barrier no perceived benefit	Not feeling or seeing a beneficial change
Barrier not understanding why you do things	Not understanding why you reach for the foods you do or why your habits are what they are
Barrier rebel against professionals	Any comments, perceptions or discussions which allude to the rejection of professional, governmental advice or regulations. It is this attitude or approach which may make dietary change or adherence to recommendations difficult. This can be a view held by the individual or talking about what others may think.
Barrier to change (emotional)	Discussions around how certain emotional states towards eating present as a barrier to dietary change
Boredom	Eating caused by being bored
General emotions and eating	Connection for comments regarding general comfort eating, or emotions and eating being linked
Judgement	Feeling judged by eating habits

NAME	DESCRIPTION
Negative emotions to wrong habits or eating	Negative emotions caused by eating the wrong foods, deviating from the study or not doing what they wanted and failing
Sad	Feeling sad or depressed can lead to reaching to foods you are trying to avoid, or undertaking habits which you didn't want to do
Stressful situations or pressure	Pressured environment or stress can lead to worse eating or habits, also deviation from eating plans, or a negative consequence in eating or habits
Barrier to change (environmental)	
Barrier - non supportive comments	Non supportive comments from family and friends
Barrier bad food proximity or accessible	Food item is within the household or very easily accessible.
Sugar is in everything	Sugar is very prevalent and in a lot of foods, difficult to avoid
Barrier food not available	The food you want to eat is not always available, can't eat what you want to when trying to find a reduced food or drink item.
Barrier incorrect or misleading or missing food labelling	Information on food labels is either not present such as not always colour coded, the wording misleading, for example saying no added sugar when free sugars are present. Some foods not having information at all, such as baked goods. All this acting as a barrier to making an informed choice.
Barrier living facilities	Not having the facilities to help follow this recommendation, or reduced living facilities negatively impacting individuals capabilities to adhere to recommendations or make the dietary changes they want to
Barrier society habits	The cultural habits we have such as, increased processed foods and certain meal or recipe options acting as barriers to change.
Barrier sugar prevalence	References to the larger prevalence of sugar in foods
Barrier supermarkets	Talking about the layout of supermarkets, or till point foods. References the environment when food shopping as a barrier to make healthier choices OR more likely to choose unhealthy food items.
Barrier travel	Being in a place with unfamiliar food choices, away from the usual food shops or having the grab food while travelling being the factor which presents as a barrier to making healthier food choices.
Barrier to change (habits and lifestyle)	
Barrier - Compensatory food increases	Have reduced one food group but subsequently have increased intakes of other food groups.
Barrier - Hard to reduce already low intakes	
Barrier - irregular eating	Barrier irregular eating habits or consuming foods at unusual times
Barrier - timing of eating	Comments regarding the timing of eating being a barrier to eating better or adhering to recommendations
Barrier already restricted eating	Already being a vegan or vegetarian , or having some other kind of dietary restriction limits the changes they can make
Barrier being at home	Being at home is a barrier to potentially better eating habits
Barrier cooking for family	Less control when cooking meals as have to factor in choices that the whole household will enjoy, not just the individual who is following the recommendation
Barrier cooking skill	Not having cooking skill can be a barrier to dietary improvement

NAME	DESCRIPTION
Barrier eating and shopping habits	References to eating practises or shopping habits that lead to increased intake of foods wanting to reduce.
Barrier effort	
Barrier exercise habits	Exercise habits are in conflict with the recommendation, or dietary change. Therefore, making adherence to the recommendation difficult presenting a barrier.
Barrier job	Job or work has made making dietary changes challenging. Comments about this and how it has impacted adherence to the recommendations
Barrier poor planning or prep	
Barrier secret eating	Eating in secret or trying to hide intakes
Barrier snacking	Snacking is a barrier to eating better overall
Barrier time pressures	Time being referenced as a reason for limited adherence to dietary change or reasons why it has been difficult to implement.
Barrier weekends	
Barrier to change (physical)	
Barrier energy levels	Having low energy and needing a pick me up from food, difficult to adhere during those points. Also when energy is mentioned as something that the individual struggles with in regards to the recommendation and adherence
Barrier habitual	Societies of and individuals previously habitual intakes and habits and therefore taste preferences are a barrier to choosing different foods or changing their diet.
Barrier hunger or dehydration	Having not eaten or drunk anything, negatively impacts choices
Barrier sugar removal negative physical	Negative physical symptoms of the removal of sugar from the diet, for example, lack of energy, shakes and headaches
Barrier to change health being ill or not	Ill health or health conditions negatively impact adherence to recommendations. Direct barrier. Or not being ill can impact your motivation for change
Barrier hormones or genetics	Conditions which cannot be helped, such as hormones or genetics or allergy
This food group is addictive	Food group to reduce is difficult as it is addictive
Cravings or food desire	Speaking about craving for food groups or specific foods, the desire to eat, taste or consume it
External factors and environment	
Food labelling for achievability	Impact of food labelling for making it easier to achieve dietary goals and make more informed choices.
Healthy food options needed	Comments in regards to greater need healthier food outlets, and healthier food choices and options being available with outside of the home.
Less control over eating when outside home	All references to when eating outside of the home leads to less control over eating, less choices available.
Facilitators to change	
Facilitator (attitudes)	
Facilitator accustomed to changes or new taste, no difference than before	Have now got accustomed to the taste, habit or food change. They are happy with the new habit or change and it feels like normal.

NAME	DESCRIPTION
Facilitator and driver - health for family and children	Dietary change of better health for self and family is a described as a driver for dietary change.
Facilitator broader alternatives acceptable	Acceptability of foods once avoided, specifically those that are alternatives for the food group cut out or aimed to reduce
Facilitator change takes time	Attitudes, perceptions and behavioural change takes time
Facilitator Committed and motivated	Perception and attitude of being committed to the project
Facilitator enjoy food	
Facilitator Enjoyed food group reduction	Positive emotion and feeling with having limited the specific food group
Facilitator risks and benefits knowledge for change doing it for self and health	Need to understanding the risk and benefits of dietary change. The justification of why it is needed for health
Facilitator staying positive consistent	Description of not letting a bad day of eating 'knock them of the wagon', to not get stuck in a negative mindset around eating and stay positive.
Facilitator to change attitudes	Description of it attitudes to eating can change it will drive a change in the choices.
Facilitator Understanding your issues or problems around food	Understanding the issues or problems you have in relation to food intakes
Facilitators permissible non-adherence foods and time periods	Being able to take a break from a recommendation helpful for longer term adherence. Includes allowable treats and food items time to time
Facilitator (emotional)	
Facilitator feeling positive about self	
Facilitator less guilt or negative emotions	Less negativity or emotions around diet and dietary habits
Facilitator less stress	Living in a less stressful environment
Facilitator shock over amount consumed unintentionally or in foods	Emotional description of shock or surprise at the amount of sugar that is in processed foods or those that have been consumed unintentionally. This shock is then a driver for not wanting to further choose those foods. Its new information that has had an emotional impact likely to change intakes for the positive.
Facilitator weight gain fear limits intakes	Fear of gaining weight by eating certain foods limits the amount consumed.
Facilitator (environment)	
Facilitator cooking facilities	Having access to good cooking facilities
Facilitator eating at home	Having more control of choice of intakes at home
Facilitator food group avoidance	Avoidance of adverts or physically seeing the food to help with not consuming foods you want to avoid.
Facilitator guidance and support similar mindsets in friends an family	Guidance and support in making changes but distinct from recommendations in that you are not being told or forced to do something.
Facilitator healthy convenient choices	Having convenient healthy food choices would be a facilitator to improving diets.
Facilitator healthy society	Living in a healthy society would have impact on others in a positive way regarding diet and dietary health
Facilitator not having food group accessible	Not having the food item or group accessible at home or near
Facilitator supermarket availability	Having access to good quality shopping facilities

NAME	DESCRIPTION
Facilitator work environment	Being in a work environment rather than at home, is a driver for better habits.
Facilitator (habits and lifestyle)	
Facilitator meal planning helps healthy choices	Meal planning can help with making healthier choices.
Facilitator being financial able	Being able to afford the foods you want to eat and are healthy
Facilitator control over eating decision making and shopping	Control over the food that is brought into the home by being the person that does most of the food shopping and cooking is a facilitator as able to control what food is around.
Facilitator Enjoy food and cooking	Having an enjoyment regarding cooking and liking of different foods
Facilitator exercise	Exercise helps with healthy eating habits or health
Facilitator food shopping habits	
Facilitator habitual	
Facilitator less socialising and eating out	Eating out and socialising in relation to food is minimal
Facilitator portion size, reduction not removal	Better control around portion size would help with dietary intakes when following recommendations.
Facilitator seek help	Seek help to support dietary or habit changes
Facilitator set meal times or more regular eating	Having set meal times can help wither adherence to recommendations.
Facilitator slower eating	Habit of not rushing eating, eating slowly and being more mindful of meal times
Facilitator solo diet	Living alone is a facilitator for dietary change as do not have to consider what other people want to eat.
Facilitator time	
Facilitator tracking intakes	References to dietary intakes is helpful for reducing intakes of a food group.
Facilitators simple gradual changes	Simple, or gradual changes are easiest to implement and will help with making dietary changes.
Facilitator fresh cooking	Cooking from scratch or cooking using fresh ingredients, not packaged or processed help with eating better and more beneficial dietary habits
Facilitator larger reduction needed - easier to change	The change of intakes was easier as the previously had consumed a lot of this food item, therefore there was more options to reduce from
Facilitator (physical)	
Driver to change external health or age	Having an external health condition can be a driver for dietary change.
Negative physical feeling after reintroducing food item	Having cut out the food group or item, having them again results in a physically negative experience
Purposeful eating	
Weight loss motivator	Motivator for dietary change being weight loss
Family, friends and household influences	
Different eating habits to FF	Having different eating habits to FF can make dietary changes difficult

NAME	DESCRIPTION
FF can influence diet change and intake	Descriptions of how friends and family can influence diet change and intakes in general. Does not describe that persons situation but circumstances in general
FF comment extreme adherence of individual	Comments from friends and family that the participant, talking about, did too much or went too far with following the recommendations
FF influence some individuals positive choices	Friends and family can influence individual to make positive food choices
FF influence to make negative choices	Friends and family can influence the individual to make negative food choices
FF support individual in changes	Friends and family support making changes, both emotionally and practically
FF upbringing	Upbringing can influence your dietary habits
FF want to have fun socially	Want to have a nice time with friends or family and not thinking about consumption
Influence of hearing others have better habits	Hearing that other people are eating better, or have better habits can be a reminder or driver to do that yourself
Influence of partner of food intake for self	Partner can have an influence on the individuals dietary intakes
Influence on household diet	Influence of following this recommendation has linked to other members of the household thinking or changing their own diet
Influence on others (positive)	
Making changes with another	Having a friend or another person, where you are both trying to make dietary changes can be supportive and help
Negative emotion from FF caused by positive adherence	Changing of dietary intakes or habits can cause negative emotions where eating with others
Self improvement can create social difficulties	Dietary change for the self can highlight where others are also not healthy. This may be negatively perceived and the individual may face social difficulties from the views of friends and family.
Socialising not food focused	Meeting with friends and family, but not having food being the centre or the activity
Temptation from household or others	Family members or those within the household having some of the food group which the individual is trying to limit - is a temptation.
Food group 'cut out' or avoided	Food group cut out of completely removed from the diet, this food item is avoided to limit intakes. Just not chosen to consume items that are likely to contain this food.
Food logging	
Logging affects food planning and meal prep	References to the fact logging intakes was a facilitator in meal prepping and planning.
Logging affects intakes	References to talking about how dietary logging or the recording of diet diaries has impacted the choices they make around food intakes. This includes both specific foods and also inferences on 'healthier' or 'better' choices.
Logging for increased awareness	Dietary logging has increased awareness, mindfulness around food.
Negativity towards the app and logging	Criticism of the libro app, or recording diet diaries as being difficult or inaccurate.
Positivity towards the app and logging	Recording of the diet diaries and logging foods was easy. Does not reference the impact of this, just whether the experience was described with positive language.

NAME	DESCRIPTION
Food swaps or substitutes or change	
Alternative foods maybe not any healthier	The foods that have been replaced may not be healthier than the ones you have cut out.
Change to meal additions	Change to condiments or drinks, food or drink items that accompany meals have changed
Food and recipe variation increase	There has been an increase in the variety of foods, recipes and meals.
Food sensitivity alcohol	Heightened physical symptoms after consuming alcohol as a result of reducing food group.
Food swaps increase achievability	References to that swapping foods increases the achievability of the recommendation.
Substitute difficult for this food group	Difficult to reduce this food group by substitution.
Substitute or swap foods to reduce	To reduce intake of food groups, use swaps, substitutes and alternatives. All instances of swaps used to reduce intakes and make dietary changes.
Thinking about swaps and alternatives	Thinking about what foods you could substitute or swap, whether that is to use them, or potentially incorporate them
Free choice	
Can't rely on individual alone to make dietary change	There needs to be some control or efforts from gov or indsutry to help guide others to make changes
Free choice self responsibility for intakes	The individual not only has free choice but there is description of personal responsibility for dietary intakes and health choices.
Individuals have free choice	Answers of yes to the question is it all up to the individual and their free choice? Plus general references to intakes being down to the individuals choice.
Not up to individual and free choice	
Yes free choice but we need knowledge	Yes individuals have free choice, but only if they are empowered to make those decisions with knowledge or education
Government and industry and policy	
Gov or industry have negative influence	They have a negative influence on diet or foods
Gov or industry are failing at labels	Labelling is not done well and the gov or industry are failing, they should do better
Gov or industry have a role or responsibility	General comments regarding the role the government or industry have
Gov or industry to influence labels	To improve or influence food labels
Government and industry influence intakes	
Government can't force people to change diets	The government can't force people to change their diets
Government food labelling is better	Description that food labelling is better, when discussed in reference to the impact the government has.
Government influence on advice provided	Government should have a direct influence on the dietary advice that is provided, this includes both in official and unofficial channels. Such as journalism and the spread of misinformation, there should be more control and regulations on this.
Government influence on education	Government should influence education around healthy choices and diets
Government to influence food prices to help	The government should influence the price of foods to help individuals with making healthier choices, or making healthier choices more financially viable

NAME	DESCRIPTION
Industry deception, just business out for themselves	Descriptions of industry and government deceptions in regards to foods available and the production of processed foods and unhealthy diets. Conspiracy theories may also be included.
Industry or gov could do more	
Industry trying to reformulate	Comments that the food industry is trying to reformulate their products
Industry unnecessary or harmful ingredients	References to food industry having formulated products with too many ingredients or unnecessary ingredients or products that contain harmful products
Professional positive influence	Professional individuals and governing bodies can be a positive influence on diet and health
Responsibility of government in regulations around food	It is a responsibility of the government to reduce the availability of fast food.
Responsibility of government to influence healthy choice availability	It is the responsibility of the government to ensure there are healthy choices available
Restrictions regulations on fast food availability	There needs to be some control or regulation around limiting the unhealthy options in the environment
Sugar tax	References to any mention to sugar tax
Habits	
Habit changes	
Habit change alcohol	Alcohol habit has changed
Habit change breakfast or eating early	Change to breakfast eating habits or eating early
Habit change eating more	There has been an increase in the amount consumed
Habit change eating more fruit and veg or fresh foods	Description of habit change as eating more fruit
Habit change eating time	Time for meals or eating has changed
Habit change food variety	Habit changes to food and diet variety, in recipes, meals and food items
Habit change harder when older	Changing your habits is harder when you are older
Habit change increase exercise	There has been and increased in the amount of exercise
Habit change increase water consumption	There has been an increase in the amount of water consumed
Habit change less baking	Not baking as much
Habit change less fizzy drinks	There has been a reduction in sugary drinks or fizzy drinks in general
Habit change less meal skipping	Not skipping meals as often
Habit change less snacking or eating	Description that there has been less snacking, or selection of grab and go food items
Habit change more savoury	Choosing more savoury, high protein or reduced sugar items
Habit change new habit	Creating or exploring new habits in order to make this dietary change
Habit change planning or meal prep	Change of habit to increase the amount of meal planning or meal prepping that is being done
Habit change supermarket shopping	Descriptions to change of habits in regards to supermarket shopping
Habit change to fresh cooking	Descriptions of change of habits to more fresh cooking

NAME	DESCRIPTION
Habit changed processed food or (unhealthy food) reduction	Habit change of a reduction of processed or packaged foods
Habit changes are additive	One change leads to others.
Habit had changed generally yes	Yes habit has changed
Habit once changed then stick to it	Once a change has been made, the individual describes being able to stick to it. Or describes not going back to a previous habit
Lifestyle change additional to recommendation	There have been additional lifestyle changes outside of the recommendation
Previous habits	
Habit previously was to eat same foods	Previous intakes of foods was to consume the same items
Previous habit eating impulsive eating or mindless eating	
Previous habit processed foods	Previous habit was to consumed more pre packed, microwave or processed meal items. Also include processed snacks such as chocolate, crisps and sweets
Snack change	
Improvements to recommendations	
Improvement feedback	Recommendation could be improved via more feedback of some kind.
Improvement of recommendation to be made more simple	Recommendation could be improved by making them more simple and understandable
Improvement to provide more recommendations	Recommendation could be improved by providing more information or more dietary change choices
Individuals attitudes and perceptions to foods	
Avoidance or negative view of artificial	Description of the reasons or statements of people saying that they do not consume artificial sugars, such as sweeteners and why. Also include negative feelings towards more 'artificial' food items
Favour towards non-artificial	Description of favour towards non-artificial sources of sweetness
Food status as treat	Food group perception is something more as a treat, or not as commonly consumed.
Foods labelled as bad, naughty (negative words)	Food items are described as bad, naughty or in a negative way
Individual knows their body best	Perception that the individual knows their body the best and what is healthy or unhealthy for themselves
Natural eating concept positive	References to more 'natural' foods and ways of eating being more positive
Perception some foods 'not allowed'	Perception that the food group asked to reduce is not allowed
Some foods not consumed every day	Some foods should not be consumed everyday, they are not regular foods you should be consuming
Individuals perceptions of self	
Feeling the odd one out	Following the recommendation made them feel on the outskirts socially, or different from their friends and family
Perception diet is already good OR healthy OR already following recommendation	References to the individual thinking their, and their households diet already being good / healthy. They were already fairly close to or good at the dietary recommendation they received.

NAME	DESCRIPTION
Perception of self and other being in control of diet	Answers that nothing is out of their (or others) control in terms of diet, they are in control of what they consume.
Is fruit allowed	
Knowledge or education	
Barrier knowledge or lack of understanding	Not understanding the recommendations, or not having the knowledge to be able to do them.
Education for better achievability	Description of if there was increased education around food and diet it would increase achievability of recommendations
Feeling uneducated	Comments regarding individual feeling uneducated in regards to dietary intakes
Has expanded own knowledge through research	Individual has done their own research and expanded their knowledge outside of just the information provided in the recommendation
Knowledge about food already had	They already had knowledge about foods already
Knowledge about food labels	Statements which show their present knowledge about food labels
Knowledge about health and diet already	Already well informed regarding the relationship between diet and health already
Knowledge driver of habit change	Descriptions that having more knowledge is a driver of changing your habits
Knowledge improved	Answers and evidence that show their knowledge has been improved from the recommendation and research study
Knowledge starting education early in life	Education around foods should start in childhood
Knowledge teach cooking skills	Descriptions that they should increase knowledge for dietary change by teaching cooking skills
Misinformation or confusion or conflicting food messages	Information in society presents a conflicting or confusion picture on food and diet. There is also misinformation in society, where adverts or labels are wrong
More education and information needed	More education around foods and dietary intakes is needed, infers more likely to adhere and do better following dietary recommendations
No prior education on foods	Statements of having no prior education on dietary intakes or foods
Mental aspects positive change	Positive impact from the recommendations or dietary change on mental
No changes or influence	
No affect on knowledge	Recommendation had no affect on knowledge.
No change eating frequency	No change to number of times eat throughout the day.
No change in taste or food pleasure	Recommendation resulted in no change in taste or food pleasure.
No change in views of diet and health	Recommendation did no change or impact view on the relationship between diet and health.
Just reinforced view of diet and health	
No change physical	
No change to cooking frequency	There was no changing in the frequency of cooking.
No change to day to day or life	The recommendation did not drastically impact their life, this includes the answer no to the question of if the recommendation affected their day to day life.
No change to eating behaviours	Participant answered no to asked if they had experienced any changes to their eating behaviours or habits.

NAME	DESCRIPTION
No change to foods eating	There was no change to the foods they were eating.
No changes general comment	Just a general comment to say they had not experienced any changes
No influence of family and friends on goals	Family and friends did not have an influence on them achieving dietary goals.
No influence or affect on others	The individual did not have an affect or influence on the dietary intakes of others or their lifestyles.
No unique characteristics stopping achievability	There was nothing unique stated by the participant as being able to affect their achievement of the dietary recommendations.
Not in control - food allergy	
People will do what they want	
Personality or character traits negative for adherence	Personality or character traits negative that would be negative for adherence to the recommendations or dietary change
Being impulsive	Being impulsive around eating or food
Easily influenced	Comments or inferences of being easily influenced
Forgetting to follow	No remembering to reduce
Lack of self discipline or lazy	References to self discipline, the lack of or inferring it is wanting in the individual
Lack of willpower	Not having the willpower, inferences or descriptions
Love of eating	Description that they love eating as a reason to not change their diet
Needing that food item	Comment regarding that they are someone that needs this food group
Not wanting to take responsibility	Individual not wanting to take responsibility for intakes
Quitting fat the first hurdle	Giving up on dietary change quickly and easily
Rules for following the advise	Describes reasons for needing additional information, infers as a reason why it means they could not follow the advise
Short term pleasure quick fix	Needing food quickly and easily and not wanting to put the effort in
Unwilling	Not willing or wanting to make a change
Personality or character traits positive for adherence (willpower, strong, determined)	Needing to have strong determination and willpower to achieve dietary goals, talking about needing or having that character trait or personality trait. Personality or character traits negative that would be positive for adherence to the recommendations or dietary change
All or nothing type	
Motivation for sustained change	They have the sticking power and drive to make a long lasting habit change
Not easily influenced and disciplined	Individual is stubborn or not easily influenced by others, also includes strong willed or determined. Having self discipline
Personality interest in nutrition and health	Personal interest in the subject of nutrition and health.
Will put in the effort	Individual wants to put in the effort and work to make dietary changes
Willingness, want, or ready to make a change	Wants to make and change, is willing to undertake the challenge of dietary change.
Willpower to resist temptation	Despite being tempted still not able to have the food group, and needing to have strong willpower to resist having that food even if they want it.

NAME	DESCRIPTION
Physical aspects and change	
Physical change improved sleep	Descriptions of sleeping better, different from having more energy. Refers specifically to sleeping
Physical change less hunger	Staying fuller for longer, not feeling as hungry
Physical change less pain	Less aches and pains physically
Physical change more energy	Individual has experienced a physical change of increased energy
Physical change skin improved	Skin is physically improved or better quality
Physical change weight (positive)	Weight change as a result of the recommendation or study
Physical general changes in body and wellbeing	General not specific comments regarding positive changes in physical health and wellbeing
Physical negative foods affects	Negative physical affects from changing intakes, or anticipated negative affects if person was to make a change.
Physical stronger reaction to sugar	Individual describes physically strong or heightened reactions to the food group.
Price, cost, affordability	
Barrier current supermarket prices (healthy expensive, junk cheap)	The current supermarket prices make it difficult to eat well, includes descriptions of healthy food being more expensive and junk, unhealthy or high sugar, fat, salt foods being cheaper.
Decrease price of healthy food	Healthy food should be cheaper, less expensive, decreased in price. Made more affordable
Healthy food is not always more expensive	Describing that healthy food is not always more expensive to buy.
Increase price of unhealthy food	Unhealthy food should be increased in price, taxed more, or be less affordable
Price influences intakes	Comments regarding price and cost of food being a large influence regarding diet and dietary change
Recommendation achievability	
Recommendation a challenge	Recommendation being described as a challenge, or set out as a challenge. Different from difficult or unachievable.
Recommendation difficult or unachievable	General descriptions of the recommendations being difficult to achieve
Recommendation difficult (public)	Recommendation is difficult for the public overall.
Recommendation difficult (self)	Recommendation was difficult or unachievable for the individual
Recommendation difficult long term (public)	Recommendation would be difficult for the public with reference to long term it being harder to maintain.
Recommendation initially difficult	Description of the recommendation being hard at the beginning of the study to implement, or if individuals are trying to make changes in the future it is harder at the start.
Recommendation easy and achievable	Generally, references to the recommendation being easy and yes answer to the question whether or not the recommendation was achievable
Recommendation achievable (public)	Yes the recommendation is achievable for the public
Recommendation achievable (self)	Yes the recommendation is achievable for the individual
Recommendation achievable short term	Recommendation was achievable but only in reference to a short-term time period.
Recommendation aspects (negative)	Negative comments regarding the recommendation or following it such as, boredom of following it, being too generic, not the best for health, unclear, not enjoyable, having too much to now think about.

NAME	DESCRIPTION
Recommendation aspects (positive)	General comments regarding the recommendation being, clear, good, personally beneficial, and healthy. Influencing dietary choices in a positive way
Recommendation changes food selection	Directly referencing the recommendations as having impacted their food selection.
Recommendation limited food choice for treats	The recommendation led to having limited choices in food items and selection
Recommendation overconsumption awareness	Recommendation has provided awareness of what intakes should be, and this awareness has led to knowledge of when overconsumption. In both own and other people's dietary intakes
Special occasions increase adherence difficulty	Special occasions increase adherence difficulty due to more temptation, and peer pressure
Taste,	
Eating pleasure food enjoyment change (positive)	The appreciation and pleasure of eating the food has changed for the positive.
Interest personal taste intensity	Interest in if the food group is going to taste more intense, or anticipation of a taste change even if they have not yet experienced one.
Pleasure of food enjoyment change to no longer liking	Change in tastes to now no longer like certain foods or drinks
Taste can be a barrier	Description how the tastes of food can be a barrier or limiting factor for change, especially in regard to short term change
Taste general	General comments regarding the taste of food or taste profile of the diet
Taste is enhanced	Certain tastes are described as stronger or more intense
Taste perception has changed	Taste of food items has changed.
Taste change (negative)	Negative taste changes and affects
Taste change (positive)	Positive taste changes
Test day encourages taste and intake awareness	References attending the test day and the impact of that in dietary intakes and awareness.

Appendix 16: Baseline data tables

Table 15.1: Baseline demographic table					
		Control (58)	Nutrient (61)	Nutrient & food (60)	Nutrient, food & swaps (63)
Age		41.72 ± 12.55	42.39 ± 14	38.33 ± 12.15	42.51 ± 13.41
Gender:	Male	5	7	8	8
	Female	53	54	52	55
Ethnicity					
	White, UK	51	53	50	58
	White Irish	0	2	0	1
	Other white background	4	3	6	2
	White & black Caribbean	1	2	0	0
	White & Black African	0	0	1	0
	White & Asian	0	0	1	0
	Other multiple ethnic background	1	1	0	0
	Asian Indian	0	0	2	0
	Asian Chinese	0	0	0	2
	Other Asian background	1	0	0	0
Nationality					
	British	53	56	53	59
	British/other	0	2	2	1
	Other	5	3	7	3
Occupation					
	Never worked long term unemployed	6	3	6	5
	Routine	6	4	5	6
	Semi-routine	1	5	2	7
	Lower supervisory and technical	2	3	3	4
	Small employers and own-account workers	4	2	1	1
	Intermediate	10	5	8	3
	Lower managerial, administrative	18	27	27	28
	Higher managerial administrative	11	12	8	9
Education					
	Other	1	3	2	1
	Secondary school GCSE	2	3	4	5
	BTEC/ A LEVELS / College level qualifications	21	17	12	19

Table 15.1: Baseline demographic table					
		Control (58)	Nutrient (61)	Nutrient & food (60)	Nutrient, food & swaps (63)
	Undergraduate degree	20	23	28	26
	Postgraduate degree and above	14	15	14	12
Main cook					
	Yes	50	48	43	48
	No	8	13	17	15
Religion affect					
	Yes	2	0	0	0
	No	56	61	60	63
Income level					
	Very insufficient	0	0	0	2
	Insufficient	3	8	4	8
	Sufficient	55	53	56	53
Diet-type					
	Other	3	5	3	1
	Vegan	3	1	1	1
	Vegetarian	7	7	12	5
	Omnivore	45	48	44	55
FS%		10.36 ± 5.1	10.13 ± 5.15	10.68 ± 4.78	10.19 ± 4.42
Energy(kcal)		1782.41 ± 538.13	1726.93 ± 503.3	1773.93 ± 477.71	1683.57 ± 436.93
Sugars(g)		78.1 ± 28.8	74.34 ± 27.75	72.8 ± 32.16	71 ± 30.04
Free Sugars(g)		46.11 ± 26.17	43.06 ± 23.54	47.75 ± 25.35	42.03 ± 19.16
BMI		27.51 ± 5.84	27.45 ± 5.73	28.5 ± 5.87	27.44 ± 5.56
Height (m)		1.67 ± 0.07	1.68 ± 0.08	1.68 ± 0.08	1.67 ± 0.08
Weight (kg)		76.67 ± 16.7	77.36 ± 18.71	81.16 ± 18.47	76.21 ± 16.32
Waist circumference (cm)		87.43 ± 12.23	89 ± 14.87	90.54 ± 17.41	88.38 ± 12.81
Data shown as mean ± standard deviation, total energy intakes of free sugars (FS%)					

Appendix 17: Baseline and endpoint questionnaire data tables

Table 16.1: Questionnaire values for baseline and endpoint								
	Baseline				Endpoint			
	CG	N	NF	NFS	CG	N	NF	NFS
LTES-(health score)	26.48 ± 16.68	21.49 ± 13.93	23.35 ± 16.41	25.62 ± 21.2	23.84 ± 18.25	22.02 ± 14.31	24.23 ± 17.82	25.31 ± 18.21
TFEQ-CR	51.25 ± 12.05	54.37 ± 10.6	52.78 ± 10.05	51.15 ± 11.56	52.52±11.92	54.09±9.29	53.12±9.64	52.95±11.04
TFEQ-UE	52.68 ± 13.56	50.88 ± 15	47.72 ± 13.33	54.85 ± 14.42	53.75±14.93	53.68±14.86	51.52±16.92	55.01±15.01
TFEQ-EE	47.7 ± 31.22	47.36 ± 32.39	49.81 ± 30.99	52.03 ± 28.91	52.46±30.82	50.43±32.43	56.88±31.97	52.91±30.22
FCQ-1-Health	2.9 ± 0.6	2.94 ± 0.58	2.85 ± 0.63	2.79 ± 0.65	2.97 ± 0.61	2.89 ± 0.64	2.87 ± 0.61	2.8 ± 0.58
FCQ-2-Mood	2.35 ± 0.71	2.45 ± 0.73	2.45 ± 0.65	2.25 ± 0.65	2.2 ± 0.74	2.36 ± 0.75	2.39 ± 0.68	2.22 ± 0.69
FCQ-3-Convenience	2.75 ± 0.68	2.85 ± 0.7	2.93 ± 0.63	2.84 ± 0.71	2.75 ± 0.6	2.85 ± 0.79	2.91 ± 0.64	2.85 ± 0.65
FCQ-4-Sensory Appeal	2.96 ± 0.54	2.9 ± 0.61	3.04 ± 0.5	2.99 ± 0.54	3.04 ± 0.62	2.92 ± 0.62	3.16 ± 0.55	2.97 ± 0.58
FCQ-5-Natural Content	2.63 ± 0.72	2.6 ± 0.89	2.51 ± 0.77	2.46 ± 0.85	2.63 ± 0.79	2.69 ± 0.84	2.54 ± 0.82	2.49 ± 0.75
FC1Q-6-Price	2.78 ± 0.68	2.7 ± 0.75	2.86 ± 0.64	2.75 ± 0.74	2.83 ± 0.7	2.74 ± 0.73	2.98 ± 0.69	2.8 ± 0.76
FCQ-7-Weight Control	2.44 ± 0.65	2.58 ± 0.73	2.48 ± 0.77	2.49 ± 0.78	2.43 ± 0.8	2.55 ± 0.78	2.46 ± 0.8	2.5 ± 0.78
FCQ-8-Familiarity	1.55 ± 0.51	1.63 ± 0.61	1.81 ± 0.64	1.63 ± 0.56	1.72 ± 0.62	1.75 ± 0.7	1.75 ± 0.67	1.7 ± 0.59
FCQ-9-Ethical Concern	2.08 ± 0.72	2.04 ± 0.68	2.03 ± 0.79	2.04 ± 0.74	2.17 ± 0.72	2.12 ± 0.75	2.06 ± 0.71	2.07 ± 0.75
SF36-PCS	50.89 ± 8.61	48.58 ± 9.54	50.06 ± 8.56	48.37 ± 11.36	50.59 ± 10.62	49.48 ± 10.69	52.09 ± 9.58	49.2 ± 9.5
SF36-MCS	44.66 ± 12.43	42.05 ± 11.76	43.6 ± 11.84	47.21 ± 12.07	46.92 ± 12.79	45.35 ± 13.66	44.43 ± 13.89	47.15 ± 12.3
SQ-PC1:Personal impact	2.76 ± 0.62	2.61 ± 0.63	2.55 ± 0.53	2.69 ± 0.58	2.79 ± 0.63	2.61 ± 0.57	2.62 ± 0.51	2.76 ± 0.53
SQ-PC2:Personal management	3.2 ± 0.58	3.23 ± 0.49	3.22 ± 0.55	3.18 ± 0.57	3.12 ± 0.61	2.93 ± 0.54	3.01 ± 0.57	3.05 ± 0.57
SQ-PC3:Nonchalance	3.43 ± 0.49	3.51 ± 0.55	3.44 ± 0.62	3.51 ± 0.6	3.4 ± 0.61	3.41 ± 0.55	3.42 ± 0.71	3.47 ± 0.59
SQ-PC4:Negativity	2.97 ± 0.52	2.96 ± 0.47	2.83 ± 0.53	3.08 ± 0.45	2.87 ± 0.58	2.84 ± 0.45	2.85 ± 0.51	3 ± 0.47

Table 16.1: Questionnaire values for baseline and endpoint								
	Baseline				Endpoint			
	CG	N	NF	NFS	CG	N	NF	NFS
SQ-PC5:Perceived understanding	2.89 ± 0.55	2.91 ± 0.57	2.83 ± 0.61	2.93 ± 0.67	2.8 ± 0.68	2.87 ± 0.72	2.77 ± 0.61	2.86 ± 0.65
SQ-PC6:Perceived Nonautonomy	2.67 ± 0.59	2.64 ± 0.74	2.59 ± 0.75	2.73 ± 0.66	2.58 ± 0.78	2.5 ± 0.76	2.45 ± 0.79	2.52 ± 0.67
BMI	27.51 ± 5.84	27.45 ± 5.73	28.5 ± 5.87	27.44 ± 5.56	27.44 ± 5.83	27.24 ± 5.8	28.12 ± 5.81	27.09 ± 5.32
Height (m)	1.67 ± 0.07	1.68 ± 0.08	1.68 ± 0.08	1.67 ± 0.08				
Weight (kg)	76.67 ± 16.7	77.36 ± 18.71	81.16 ± 18.47	76.21 ± 16.32	76.5 ± 17.11	76.64 ± 18.55	79.72 ± 17.34	75.11 ± 15.4
Waist circumference (cm)	87.43 ± 12.23	89 ± 14.87	90.54 ± 17.41	88.38 ± 12.81	87 ± 14.61	87.66 ± 15.96	87.74 ± 15.63	86.55 ± 12.75

Data shown as mean ± standard deviation, Three factor eating questionnaire (TFEQ), cognitive restraint (CR), emotional eating (EE), uncontrolled eating (UE), 36-item short form survey (SF36), physical component score (PCS), mental component score (MCS), sweet questionnaire (SQ), food choice questionnaire (FCS), leisure time exercise score (LTES), total energy intakes of free sugars (FS%)