Decreasing physical activity levels across religious Sikh male South asian migrant population in Kent, UK: A public health concern

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Abstract: Physical activity (PA) plays a crucial role in reducing the risk of non-communicable diseases (NCDs). We investigated intergenerational physical activity level (PAL) among first and second generation Sikh Punjabi male subjects (n=137), recruited from two Sikh temples in Medway, UK. Employing a cross sectional survey PA was quantified using the validated Global PA Questionnaire (GPAQ). Data were analysed using SPSS 20 and Epi Info software. 91% of the subjects were classified as overweight. Mean physical activity level (PAL) range was sedentary to low levels of PA (1.45 – 1.60). Comparisons between first and second generation Punjabi male subjects showed that the two groups are equally culpable in not engaging in work-related or recreational PA, but for the second generation this is significantly lower. Low PAL is a contributory factor to increased risk and prevalence of NCDs among this population and a public health concern. Efforts to increase PA in this group should continue.

Keywords: South Asian; intergenerational; acculturation; Indian, Nutrition transition

1. Introduction

Physical activity (PA) can reduce the risk of premature death from cardiovascular disease and type 2 diabetes and sustain a healthy lifestyle [1]. Physical inactivity is associated with increases in serum insulin and insulin resistance, triglycerides, BMI and increased risk of hypertension [2]. In the UK 150 minutes per week of moderate activity or 75 minutes per week of vigorous activity to attain the beneficial effects of PA are recommended [2, 3]. Exercise for 30 min/day to 60 min/day helps to reduce total and abdominal fat and improve metabolic profiles [4] . Moreover, PA can independently

improve serum lipid profile by reducing triglycerides, LDL cholesterol and total cholesterol and improving HDL cholesterol levels and thus help to reduce cardiovascular risks [5,6,7]. Increase in PA and lifestyle modification have shown a reduced risk of diabetes [6].

South Asians (those with ancestral origins from Pakistan, India, Bangladesh and Sri Lanka) living in the UK have consistently been shown to have lower levels of PA than the general population [8, 9]. This trend begins in early life [8, 9, 11] and is likely to be an important contributor to an increased incidence of cardiovascular disease (CVD), diabetes and poor health outcomes observed in this group. Obesity is associated with increased risk of CVD and diabetes [7,10-13] and it is of concern that the incidence of obesity is high among SA.

Research indicates several factors, distinct to UK South asians (SA), which may impact on their PA levels [9-11]. Migration histories indicate that SA born in the UK report higher levels of PA than those born elsewhere [30]. Williams et al report total Metabolic Equivalent of Task (MET-min/week) were consistently lower in UK SA than in white participants (973 versus 1465 MET-min). This ethnic group difference was consistent across gender, age groups and subgroups and was independent of covariates [14, 30]. Self-reported PA patterns in SA suggest that nearly 35% of SA men were doing office service-based jobs a decade ago, (mainly seated) with commensurately low levels of PA undertaken [5, 6]. Moderate PA such as light lifting, climbing stairs and outdoor hill walking is low among SA men compared to Europeans [7, 9]. Low preference for walking and cycling is common among SA men. Previous studies have suggested that in comparison with the general population, overall participation in sports and recreational activity was less among SA men [11]. Furthermore, among the minority ethnic groups in England, SA were found to be living the most sedentary lifestyles [10]. Comparisons between SA subgroups in the UK showed that Bangladeshis were the least physically active followed by Pakistani's and those of Indian origin. Only 17% of Indians, 16% of Pakistani's and 10% of Bangladeshi's met current PA recommendations [8]. Overall, motivation and encouragement to engage in PA for a healthy life is found to be low among this population.

Acculturation and assimilation is described by Jamal [15] as unidirectional and describes the change processes that immigrants undergo once they leave their country of origin and adapt to a new country [15]. Many changes take place during this process, particularly in PA and dietary patterns. SA migrating from their "home" country experience changes in dietary intake and in PA. There is currently little evidence of changes in PA levels amongst SA group, based on acculturation for first generation and occurrence for second generation SA. Previous research indicates that Punjabis living

in the Punjab state of India have the highest rates of overweight and obesity compared to other states of India [27]. We therefore sought to examine the PA level of a parallel group living in the UK to ascertain if the picture is similar and whether any intergenerational differences occur.

Thus the research aimed to:

- Assess current levels of PA in a Sikh Punjabi male population living in Medway, Kent (UK) and compare this to current recommendations.
- Compare levels of PA between first and second generation Sikh Punjabi males living in Medway.

2. Methods

PA Level Assessment

The study employed a cross-sectional survey method. To test our hypothesis of intergenerational differences in relation to levels of PA and risk of non-communicable diseases (NCDs), the WHO Global PA Questionnaire (GPAQ) was used to measure PA among this group [17,18]. GPAQ is an indirect method of PA measurement validated by Bull, et al. [26] for universal use enabling national, regional and global comparisons to be made. The questionnaire enabled three domains of PA to be measured, namely occupational, transport (to and from work) and recreational activity utilizing 16 questions. Data collected was converted into *MET equivalents* where 1 MET equals the energy cost of sitting quietly without undertaking much activity *i.e*. a completely sedentary scenario [19]. Data analysis was undertaken following GPAQ analysis guidance provided by WHO STEPS [18]. This was further quantified as equivalent to the consumption of 1 kcal/kg/hr. To estimate the energy costs of sleeping and sitting, the Schofield Equation [19] was used. In this study, this equation was applied to help quantify (by estimation using the prediction equation and taking into account time spent per activity) energy expenditure (EE) due to sitting and sleeping. Physical activity level (PAL) was calculated using WHO/FAO predictive equations based on physical activity ratios (PAR) of the various components of daily activity []

Sample Size Calculation

Sample size was calculated based on the use of the following provisions: a statistical power of 90% ($1 - \beta = 0.9$) was sought with a medium effect size $\rho = 0.30$ and Type I error ($\alpha = 0.05$) with non-centrality parameter δ of 3.28; using a point biserial model to allow for t-tests and correlation (two tailed). The sample size computed = 109 [16]. Allowing for recruitment and retention difficulties for ethnic minorities previously reported [29] and assuming an attrition rate of 25%, based on experience from

our pilot study, the total sample size calculated was n= 136.3. A total of 137 subjects were therefore recruited to participate in the study.

Sampling and recruitment

Subjects were identified and recruited from two local Gurudwara (Sikh temple), in the Medway town chosen for their general as well as religious use. There are no known differences between the two temples as the congregation was similar in interest and religious background. The static numbers of temple attendees were obtained from temple registrations. 565 adult males aged between 20 and 60 years who were attendees at both Sikh temples met the eligibility criteria to participate. Two cohorts were recruited. Cohort A (from Gillingham Gurudwara) n= 325; and cohort B (from Rochester Gurudwara) n =240 respectively to form the combined total for the study population. In total 225 (out of 565 possible) subjects were recruited using a random stratified sampling procedure from Rochester n=113; and Gillingham n=112. In this process males from Punjabi origin were selected and for stratification Sikhs were selected at random and screened for eligibility and selection to participate in the study using inclusion/exclusion criteria identified in **Table 1**. Of this number, eighty-eight (n=88) were excluded and one hundred and thirty-seven (n=137) were eligible for inclusion in the study and were assessed for PA using the global PA questionnaire (GPAQ). Sixty-eight (n=68) subjects from (Rochester and sixty-nine from Gillingham were recruited from each temple via a simple random procedure involving Sikh male subjects within the specified age range, giving a final sample size of one hundred and thirty seven (n=137).

Table 1: Study inclusion and exclusion criteria

Variables	Inclusion	Exclusion	Remarks
Sex	Male Adults	N/A	As long as they can provide us with dietary intake & food preparation information.
Age	(20-60 years)	<20 or 60>	Identification of diet commonly consumed by this population.
Health status	Apparently healthy individuals with no disorder/disease and therefore, not on restricted diet	Already diagnosed patients with diabetes and/or other chronic NCD	Must be familiar with traditionally consumed diet
Languages (s)	Must be fluent in Punjabi; Able to communicate in basic English	Non Punjabi-speaking; not able to communicate in basic English	
Lifestyle	Any and no restriction on religion	None	
Medication	Must be declared to be included in study	Individuals on current treatment for known NCDs excluded	
Time in the UK	Either born in the UK or resident for ≥8 years	Less than <8 years in the UK.	This cut off was used on the basis of time-related lifestyle moderation and adjustment to culture in the UK
Immigration Status	Permanently Resident	Temporary and Visitor	

130 **2.1 Data collection**

131 Subjects were interviewed using the GPAQ; each interview lasted approximately 20 minutes and was
132 conducted in English with Punjabi translation where required by the bilingual primary investigator.
133 Interviews took place in a quiet room provided at the Temple study site where subjects were invited for
134 the study and interviews were undertaken in confidence.
135
136 **2.2 Data handling and analysis**

137 The data was collated, grouped and presented in the form of tables. Data were entered into Microsoft
138 Excel (2010) and transferred into Statistical Package for Social Sciences version 20 for analysis.
139 GPAQ data collection was analysed following WHO STEPS, GPAQ V.2 procedure [17,18.
140 Conversion of 24-hour PA data into MET equivalents by quantify the energy costs of daily individual
141 activities in kcal/day and kcal/kg/day. GPAQ [17,18,19] data was used to categorize subjects into
142 different levels of PA *i.e.* Low, Moderate and High activity groups respectively. Contributions of
143 occupational and recreational PA, in addition to age-related differences in levels of PA were calculated
144 (**Box 1**).

145 **Box 1:** Calculations used for physical activity level, total daily energy expenditure & METs equivalent

PAL Calculation: {Time Allocation per activity * Physical Activity ratio (PAR/Known as Energy cost of various activity) } ÷ 24 hours

TDEE: Basal metabolic rate (BMR at particular age) * PAL

Energy Intake: (1g Protein * 4 Kcal) + (1g Carbohydrate * 4 Kcal) + (1g Fat * 9 Kcal)

METs equivalent calculation: In this study an individual's energy expenditure was calculated using GPAQ version 2 data, 4 METs is assigned to the time spent in moderate activity and 8 METs to the time spent in vigorous activities.

Types of activity were classified based on GPAQ WHO STEPS analysis guidance [17, 18, 19].

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147
148 All variables were tested for normal distribution using Shapiro Wilk test. Descriptive statistics were
149 performed and more specific significance testing using student t-test (both paired and independent)
150 was employed based on the variable set of significance. Z-tests were conducted to test the significance
151 of observed differences between the first generation and second generation parameters. Results of
152 quantitative analyses obtained are presented as means (with standard deviation and 95% confidence
153 intervals). Intergenerational differences of variables were computed. Differences of means compared
154 using the Z-test, were considered to be statistically significant at p values of ≤ 0.05.
155

156 ***Ethics statement***

157 This study was conducted according to guidelines laid down in the Declaration of Helsinki and all
158 procedures involving human subjects were approved by the University of Greenwich, Research Ethics
159 Committee (UREC/10/11.4.5.2). Permission and cooperation was also granted in writing by the leaders
160 (Granti-Ji) at two Sikh temples in Medway, Kent. Subjects provided written informed consent.

161 **3. Results**

162 **Results**

163 ***PA among Male Sikh Punjabi Population***

164 Self-reported PA among adult male Punjabi Sikh migrants (n=137) in Medway, Kent are reported.
165 Comparisons are reported for the total study sample and intergenerational comparisons (between first
166 and second generation subjects). The components of PA including employment/work transport and
167 non-occupational activities (i.e. recreational) and their contributions to PA levels in relation to age
168 groups of five year intervals are presented in **Table 2** quantified in MET-Minutes per week.

Table 2: Physical Activity converted into MET-minutes/week according to activity type (n=137)

Age Groups (years)	Participants Per Group	Activity at Work Vigorous (Mean ±SD)	Activity at work Moderate (Mean ±SD)	Travel to and from work (Mean ±SD)	Recreational Activity Vigorous (Mean ±SD)	Recreational Activity Moderate (Mean ±SD)	Total Met-minutes/ week	BMI Kg/m^2
21-25	6	60.00(146.97)	30.00 (73.48)	230.00 (258.53)	220.0 (244.95)	130(179.67)	670.0	30.68(1.41)
26-30	29	70.3 (145.3)	72.4 (163.8)	122.80 (201.0)	66.2 (168.4)	266.9 (215.5)	598.6	28.70)2.96)
31-35	30	48.00 (124.47)	94.00 (160.44)	68.67 (136.12)	84.00 (175.88)	228.00 (189.34)	522.67	27.66(2.08)
36-40	30	38.71 (121.54)	44.52 (92.91)	112.26 (195.80)	77.42 (179.46)	303.87 (208.39)	576.78	28.39(2.43)
41-45	23	15.65 (75.07)	112.17 (180.28)	120.00 (190.60)	41.74 (117.85)	260.09 (211.61)	549.65	28.80(2.42)
46-50	15	16.0 (62.0)	36.0 (74.5)	138.7 (181.2)	72.0 (126.7)	236 (176.3)	498.7	28.32(0.64)
51-55	4	0.00 (0.00)	90 (180.0)	295.0 (224.7)	0.00 (0.00)	120 (84.9)	505.00	27.78(0.69)
Mean(SD)		**36 (25.87)**	**68 (32.01)**	**155 (78.57)**	**97 (58.93)**	**213 (67.70)**	**552**	
95% CI Upper		**54.69**	**92.16**	**213.54**	**140.99**	**263.13**	**601.06**	
95% CI Lower		**16.37**	**44.73**	**97.13**	**53.68**	**162.82**	**503.91**	

Comparison of Total Daily Energy Expenditure due to different activities across age groups

The quantification of energy costs of individual PA based on the conversion from METs to energy equivalents in kilocalories (*i.e.* 1 MET = 1kcal / kg /hr.) and age-group comparisons is presented in **Table 3**. Activities have been split into various forms based on the GPAQ tool. Energy costs of sitting quietly and sleeping have been included to provide a more complete picture of the total daily energy expenditure (TDEE) estimates for each age-group category and the whole group.

The age group with the highest work-related energy expenditure (EE) due to vigorous activity was the 26 - 30 age group with a mean (SD) of 98.31(204.11) kcal /d. The 51 – 55 age group had no work-related nor recreational vigorous activity recorded. The overall group mean (SD) was 56.15 (159.45) kcal/day from work-related vigorous PA with a 95% CI of 29.54, 82.75.

Energy costs of work-related moderate PA, show that the age group with the highest energy expenditure was the 31 – 35 years' age group with a mean (SD) of 281.63 (454.00) kcal/day. The 21 – 25 age group had the lowest work-related energy expenditure with a mean value of 43.75 (107.17) kcal/day. The whole group mean (SD) EE from work-related moderate activity was 173.76 (324.58) kcal/day. Very wide SD values are observed throughout most of the age groups reflecting the lack of consistency in individual engagement in PA, of any type, at work as captured by the GPAQ.

Table 3: Total Daily Energy expenditure (EE) Kcal/ day due to various types of activity according to activity type (n=137)

Age Groups (years)	Activity at Work Vigorous (Mean ±SD)	Activity at work Moderate (Mean ±SD)	Travel to and from work (Mean ±SD)	Recreational Activity Vigorous (Mean ±SD)	Recreational Activity Moderate (Mean ±SD)	Sitting (Mean ±SD)	Sleeping (Mean±SD)	TDEE (Kcal/ day) (Mean ±SD)
21-25	87.50(0.00)	43.75(0.00)	368.07(411.92)	342.97(388.18)	218.67(303.33)	1255.80(97.84)	691.35 (68.84)	3008.10(229.73)
26-30	98.31(204.11)	108.15(249.40)	258.57(385.21)	241.38(384.38)	532.78(341.76)	1140.64(120.66)	590.10(106.44)	2969.93(509.50)
31-35	61.56(159.73)	281.63(454.00)	132.92(265.49)	188.39(350.87)	478.22(321.37)	1082.81(104.94)	533.32(115.68)	2778.86(394.28)
36-40	55.66(175.63)	126.09(257.96)	231.56(473.52)	158.81(355.98)	610.11(342.88)	1137.54(139.94)	566.02(133.21)	2885.79(260.74)
41-45	18.21(87.33)	274(360.69)	169.05(274.35)	115.43(276.14)	516.74(389.73)	1093(99.48)	568.09(83.32)	2755.33(484.09)
46-50	25.41(98.43)	95.95(215.52)	274.38(329.71)	160.65(327.00)	512.85(445.07)	1139.75(109.16)	622.75(69.78)	2831.74(510.22)
51-55	0.00(0.00)	117.30(234.60)	649.49(253.71)	0.00(0.00)	156.40(312.80)	1074.45(66.80)	532.63(73.86)	2693.34(355.94)
Mean	**56.15(159.45)**	**173.76(324.58)**	**228.08(366.32)**	**183.50(342.99)**	**509.08(360.01)**	**1122.47(119.73)**	**579.31 (109.51)**	**2852.35(512.39)**
95% CI Upper	**82.75**	**227.91**	**289.19**	**240.73**	**569.14**	**597.58**	**597.58**	**2937.84**
95% CI Lower	**29.54**	**119.61**	**166.96**	**126.27**	**449.01**	**561.04**	**449.01**	**2766.86**
p-value	**0.001**	**0.012**	**0.017**	**0.014**	**0.001**	**0.128**	**0.147**	**0.023**

193

194 ***Estimation of Energy Balance and their Association with PA Level (PAL)***

195 A summary of total daily energy intake (EI, Kcal / day) estimated from pooled means of three 24-hour
196 dietary recall data are presented in **Table 4.** Total daily energy expenditure (TDEE, Kcal / day) based
197 on calculations from GPAQ data (for occupational, travel and recreational PA) and using Schofield's
198 equation [19] (for energy costs of sitting and sleeping) are also presented. From these data, estimates
199 of energy balance i.e. EI – TDEE have been calculated and the group comparisons are presented to
200 indicate whether the subjects were in positive (i.e. > +1Kcal / day) or negative (i.e. < 0 kcal /day)
201 energy balance (EB) based on intake/ expenditure.

202

203 The data in **Table 4** show that all age groups were in positive energy balance except for the 46 – 50
204 age group which was in negative energy balance but with a very large SD value showing wide intra-
205 group variation. All age groups had excess energy intake over expenditure (EB) of at least 300 kcal
206 per day with the exception of the 51 – 55 age group with mean (SD) EB of +8.33 (1553.21) kcal / day.
207 The highest EB was recorded in the 21 – 25 age group with mean (SD) of 661.42 (956.92) kcal / day
208 followed by the 31 – 35 and 26 – 30 age groups with mean (SD) values of 516.60 (1047.88) and
209 514.21 (1515.42) kcal / day respectively. The whole group mean (SD) EB was 363.93 (1307.99) kcal /
210 day representing excess intakes with a 95% CI of 145.70, 582.17.

211

212 The reference cut-off points for classification of individuals (and population groups) as sedentary is
213 PAL ranges from 140 – 169. The PAL values presented in **Table 4** ranged from 1.53 (0.06) in the 41 –
214 45 age group to 1.64 (0.06) in the 51 – 55 age group. The overall group mean (SD) PAL value of 1.54
215 (0.07) is confirmatory of a sedentary population with a 95% CI of 1.52 – 1.55. There was no
216 significant variation in PAL among the groups (single factor ANOVA, p=0.783).

217

218

Table 4 Daily Energy Intake, Expenditure and PA levels (PAL) of a Punjabi adult male population in Medway, Kent (n=137)

Age Groups (years)	**EI (Kcal/ day) Mean (±SD)**	**Median**	**TDEE (Kcal/ day) (Mean ± SD)**	**Median**	**Energy Balance (EB) Kcal (Mean ± SD)**	**PAL Value (Mean ± SD)**	**Median**	**PAL Level***
21-25	3669.53(932.19)	3703.99	3008.10(229.73)	3336.50	661.42(956.92)	1.56 (0.08)	1.55	Sedentary
26-30	3484.13(1418.40)	3696.22	2969.93(509.50)	3036.33	514.21(1515.42)	1.54 (0.08)	1.49	Sedentary
31-35	3295.45(999.09)	3389.11	2778.86(394.28)	2735.32	516.60(1047.88)	1.52 (0.06)	1.49	Sedentary
36-40	3225.16(1076.08)	3462.11	2885.79(260.74)	2830.24	339.37(1390.92)	1.54(0.09)	1.49	Sedentary
41-45	3115.54(1115.13)	3180.97	2755.33(484.09)	2818.10	360.21(1246.45)	1.53(0.06)	1.49	Sedentary
46-50	2632.12(1420.31)	2131.50	2831.74(510.22)	2908.97	-199.62(1389.45)	1.55(0.07)	1.50	Sedentary
51-55	2701.67(1246.94)	2701.67	2693.34(355.94)	2991.65	8.33(1553.21)	1.64(0.06)	1.63	Sedentary
Mean	**3216.28(1191.64)**	**3279.64**	**2852.35(512.39)**	**2904.21**	**363.93(1307.99)**	**1.54(0.07)**	**1.49**	**Sedentary**
95% CI Upper	**3405.08**		**2937.84**		**582.17**	**1.55**		
95% CI Lower	**2998.49**		**2766.86**		**145.70**	**1.52**		
p-value	**0.037**		**0.023**		**0.032**	**0.783**		

Intergenerational Comparisons of Energy Intake and Expenditure

The PAL values in **Table 5** show that both first and second generation Punjabi males in Kent are sedentary with equal PAL of 1.54 (mean SD +/- 0.07). Total daily energy intake (EI) was significantly different between first and second generations. The mean (SD) EI was 3079.04 (1174.97) kcal/day in the 1st generation and 3517.95 (1186.08) kcal/day in the 2nd generation (p=0.045) with a difference in means (95% CI) of 438.21 (5.681, 870.74). Differences in the magnitude of total daily energy expenditure (TDEE) between the 1st and 2nd generation were observed. These differences were not statistically significant (p=0.085). However, despite this both the 1st generation and 2nd generation are sedentary.

Table 5 Age and inter-generation differences in PA and energy balance

Variables*	**Generations**		**Difference in Means**	**95%CI Lower**	**95% CI Upper**	**p-value**	**Group (n=137)**	
	1st (n= 43) Mean (±SD)	**2nd (n=94) Mean (±SD)**					**Mean (±SD)**	**Median**
PAL	1.54(0.07)	1.54 (0.07)	0.0031	-0.024	0.0304	0.819	1.54(0.07)	1.49
TDEE (Kcal/day)	2803.59(524.91)	2960.05(471.67)	156.45	-22.06	334.98	0.085	2852.35(512.39)	2904.21
EI (Kcal/day)	3079.73(1174.97)	3517.95(1186.08)	438.21	5.681	870.74	0.045	3216.28(1191.64)	3279.64
EB (Kcal/day)	276.14(1329.24)	557.89(1253.07)	281.75	-184.96	748.47	0.256	363.93(1307.99)	333.04
BMI (Kgm^{-2})	28.3(2.2)	28.69(2.63)	-0.368	0.550	-1.287	0.475	28.44(2.34)	28.22

***PAL = PA Level; * TDEE= Total Daily Energy Expenditure; * EI = Energy Expenditure; *EB = Energy Balance**

Energy balance (i.e. EI – TDEE) comparisons showed that 2nd generation had a higher EB of 557.89 (1253.07) than the 1st generation whose EB was 276.04 (1329.24). The difference in means (95% CI) was 281.75 (-184.96, 748.47). These differences suggest that both groups expend energy to similar extents. However, the 2nd generation's energy intake significantly exceeds that of the 1st, and that is the main source of difference between these two largely sedentary inter-generational groups in this male genetically, culturally and religiously homogenous population. Type of occupation among the Sikh Punjabi population living in Medway is presented in **Table 6** and indicates largely sedentary activity by the majority.

Table 6 Type of occupation* among Sikh Punjabi male population living in Medway, Kent, UK

Occupation Type	Activity Type	Total (n=137)	% Occupation Type
Retired / Not working	Nil	0	0%
Administrative Office	Sedentary	66	73% Sedentary
Business	Sedentary	35	
Builder/developer(Manual Worker)	Active	29	
Manual Labour	Active	7	27% Active

*Types of occupation is based on international standard classification of occupations ISCO-08 [31]

4. Discussion

The present observational study of a cohort of Indian Punjabi Sikh males (age 20 to 60) have lower energy expenditure, a lower PAL, than expected and are engaged in largely sedentary-type jobs. PA is an independent risk factor for NCD's and it has been reported that PA, especially moderate to high PA may reduce the risk of cardiovascular disease by half [20,21]. Using WHO recommendations a PAL of 1.70 to 1.99 is expected for this population group which equates to moderately activity. The findings show the range of PAL is 1.45 – 1.60, which classifies the entire sample as sedentary or involved in low levels of PA (as supported by existing literature).

More importantly, comparisons between first and second generation migrants unique to this study show that the two generational groups are equally culpable in not engaging in PA, be it work-related or recreational and are falling short of the current UK Department of Health recommendation for PA [3]. Furthermore, the MET-Minutes per week estimations provide average values for the whole sample which falls short of 600 MET-Minutes per week *ie* the threshold for sedentary activity. This low level of PA puts this population at a higher risk of NCDs [24, 25].

This population of Punjabi males in the UK when compared to their age-matched cohorts in the Indian and Pakistani Punjab, are more engaged in ‘sedentary’ service type jobs (about 73% of the sample population) and only 27% engage in manual labour of significance. In comparison, those of a similar age range in the Indian Punjab are mostly engaged in agricultural type manual labour (70%) compared to service industry type jobs (30%) [22,23,26]. The Indian national statistics observe that the Punjab Province has the highest rate of overweight and obese people at just over 30% in the whole of India, in a country where 70% of the population is purported to be engaged in manual labour [27]. Additionally, PA due to transport (e.g. walking, cycling to and from work) is likely to be much higher in India than among their counterparts in the UK [25].

Energy intake and expenditure comparisons (**Table 4**) show clearly that this population is in positive energy balance across the different age groups and both generations. The second generation has a significantly higher energy intake ($p=0.045$) compared to the first generation and have a higher BMI (**Table 2**) although the latter differences were not statistically significant. Both groups have BMI values above 28 kgm^{-2} and 91% of the subjects are at least overweight (using normative BMI cut-off criteria). However, there is growing evidence to suggest that at lower BMI people of Indian origin have a much higher cardiovascular and non-communicable disease risk compared to Caucasians and therefore the risk is greater [24, 25, 28, 29]. Using the Asian specific cut-off points developed for BMI [32] more of this group would be classified as overweight and obese.

Concerns about low PA among the SA migrant population have been previously expressed [8,9,10,11] although these studies have limitations. Importantly, this study finds that the second generation UK Sikh Punjabi male is less physically active than the first generation, a result which is contrary to that previously reported [10]. Furthermore, given the three-fold increase in the prevalence of overweight and observed in the sample population (compared to their aged-matched cohorts in the Punjab, India), of particular importance as a risk factor is the possible impact of long term migration and a change of environment on physical growth, food-related behaviours, occupational differences and sedentariness in this homogeneous migrant adult male population, originating from the Indian Punjab and domiciled in the UK.

It is clear from this research that there are intergenerational differences in PA levels in a homogeneous group of migrant male adults, and despite differences in social exposure e.g. education, social mobility, employment in incomes, we cannot assume the second generation will be more active as they are influenced by other motivators or barriers to PA including the environment. This may be suggestive of the closely linked nutrition transition observed across the world, including India [30]. The very types of occupation and low levels or work-related PA especially among the second generation underscores a need to examine ways to address overweight and obesity risks through targeted work-based interventions.

Cultural barriers have been implicated as one of the barriers to PA among SA females [1] in relation to cultural barriers which may in themselves influence parental encouragement and promotion of PA among their growing female children, which may similarly be the case for a physically inactive father – although there is no evidence to support this for south Asian males. Whilst some social-cultural and environmental barriers to increasing physical activity may be common among the SA communities in the UK, they are by no means unique or exclusive. Indeed, Jepson et al [1] suggest that interventions

should focus on motivations rather than the well documented barriers. This includes group based activities, an approach which has also been successful in dietary change in relation to obesity and weight management elsewhere.

This research has a number of limitations due to the potential bias of the sample and thus the limited external validity restricting its application to a general population. However, it does present a useful contribution to the development of our knowledge of PA patterns in this often hard to research group of participants in the UK.

Tackling the problem of obesity and chronic disease risk in population groups such as this one would require concerted, culturally and religiously targeted, focused and contextualized behaviour change programs including physical activity, lifestyle coaching and dietary behaviour change activities in convivial community settings such as temples which provide an opportunity to reach target groups. The successful recruitment of males in this study through the medium of a religious environment *i.e.* a Sikh temple, suggest that this is a useful place to develop and deliver such interventions for maximum outreach and impact.

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Author Contributions:

Conceived and designed the study: SS, PA and ZBF. Reviewed the methodology and analysis: PA, FBZ, BE. Performed the data collection and analysis: SS. Interpreted the findings: SS, PA, FBZ, BE. Wrote the paper: SS, BE. All authors edited and approved the final manuscript.

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