

1 Perceived Stress and Diet Quality in Women of Reproductive 2 Age: A Systematic Review and Meta-Analysis

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14 Abstract:

15 **Background:** Poor diet quality is associated with obesity-related morbidity and mortality. Psychological
16 stress can increase unhealthy dietary choices, but evidence pertinent to women of reproductive age remains
17 unclear. This paper systematically reviewed the literature to determine the association between psychological
18 stress and diet quality in women of reproductive age.

19 **Methods:** Medline, CINAHL, Scopus, Cochrane Library, Web of Science, and Sciencedirect were
20 searched. Data extraction was determined by the PEO. Inclusion criteria consisted of: English language, stress
21 (exposure) measured in combination with diet quality (outcome), healthy women of reproductive age (18-49
22 years old (population)). **Observational studies, due to the nature of the PEO, were included.** Quality assessment
23 used the Risk of Bias in Non-randomised Studies from the Cochrane Handbook of Systematic Reviews of
24 Interventions. Meta-analysis was conducted using random-effect model to estimate the Fisher's z transformed
25 correlation between stress and diet quality with 95% confidence interval (CI).

26 **Results:** From 139,552 hits, 471 papers were screened; 24 studies met the inclusion criteria and were
27 conducted in different countries: 8 studies on diet quality and 16 on food intake and frequency of consumption.
28 Studies of diet quality consisted of six cross-sectional and two longitudinal designs with a total of 3,982
29 participants. Diet quality was measured with diverse indices; Alternate Healthy Eating Index (n=2), Healthy

30 Eating Index (n=2), Dietary Approach to Stop Hypertension (DASH) Diet Index (n=2), Dietary Quality Index-
31 Pregnancy (n=2), and Dietary Guideline Adherence Index (n=1). Most studies used Cohen's perceived stress
32 scale and no study measured biological stress response. After sensitivity analysis, only 5 studies (3471
33 participants) were included in the meta-analysis. Meta-analysis revealed a significant negative association
34 between stress and diet quality with substantial heterogeneity between studies ($r = -0.35$, 95% CI [-0.56; -0.15],
35 p value < 0.001 , Cochran Q test $P < 0.0001$, $I^2 = 93\%$).

36 The 16 studies of food intake and frequency of consumption were very heterogeneous in the outcome
37 measure and were not included in the meta-analysis. These studies showed that stress was significantly
38 associated with unhealthy dietary patterns (high in fat, sweets, salt, and fast food and low in fruits, vegetables,
39 fish, and unsaturated fats).

40 **Conclusion:** Future studies that explore diet quality/patterns should include both diet indices and factor
41 analysis and measure biological markers of stress and dietary patterns simultaneously.

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43 **Keywords:** Diet quality, diet, stress, women, reproductive age, systematic review, meta-analysis

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45 1. Background

46 The rate of obesity has increased alarmingly in the past twenty years across all age groups, especially
47 among young adults [1]. In women of reproductive age, obesity is associated with type-2-diabetes,
48 hypertension, decreased fertility and delayed conception, high birthweight and congenital anomalies [2-4].
49 These women are at increased risk of obesity related morbidity and mortality especially during pregnancy when
50 metabolic complications might deteriorate and cause gestational diabetes, pre-eclampsia, miscarriage, and
51 various cardiovascular disorders putting both the mother and baby at increased health risk [5]. Preventing
52 weight gain in women of reproductive age through healthy diet is crucial and would benefit the next generation
53 [6,7]. Poor dietary patterns are major predictors of increased adiposity and a higher diet quality is associated
54 with reduced risk of obesity-related metabolic disorders [6,8]. Recently, diet patterns have been derived in
55 nutrition epidemiological studies by measuring the whole diet instead of single nutrients [9]. Indeed, the overall
56 food pattern is considered a more realistic approach to investigate the association between diseases and food
57 consumption rather than single nutrients [9]. Diet patterns/quality can be estimated via a posteriori approach
58 based on statistical methods such as factor analysis, or a priori- defined diet quality score which measures
59 adherence to specific dietary pattern indices such as the Mediterranean Diet Index [10]. These healthy dietary

60 patterns (e.g. Mediterranean diet) have been associated with decreased risk of cardiovascular disease, diabetes,
61 cancer, and hypertension in women of reproductive age, and this is why they are used to measure diet
62 patterns/quality in recent epidemiologic studies [11,12].

63 There are several factors that might affect diet patterns/quality such as adiposity, smoking, age, income,
64 educational level, race/ ethnicity, marital status, and psychological factors [13,14]. Particularly, there has been a
65 growing interest in the role of stress in relation to human health [15,16]. Stress is defined as an individual's
66 perception, appraisal, and response to a stimulus exhibited by the surrounding environment [17], and it happens
67 when the person's adaptive capacity is surpassed by the stimuli and demands of the environment [18]. Stress has
68 been associated with diet patterns in young adults, and the dietary responses to stress are individualized [19, 20].
69 For example, some reviews and longitudinal studies investigated the effects of stress on energy intake and have
70 found that with high levels of stress, 40% of people eat more, 40% eat less, and 20% eat the same amount of
71 food compared to that consumed in the absence of stress [21,22,23]. The variance in the response to stress might
72 be due to the duration of exposure to stress, the type of stressor, and the variation in the level of hunger and
73 satiety at the start of the studies [24]. For example, mild/chronic stressors (such as long-term poverty,
74 unemployment, unhappy marriage, etc.) increase the desire for food intake and binge eating, while sever/acute
75 stressors (such as an upcoming work deadline or exam) induce restriction of food intake [24]. It is fundamental
76 in this context to understand the types of food that are consumed and restricted under stress in order to estimate
77 its health consequences. In general, studies have reported that highly stressed participants tend to consume
78 hyper-palatable foods that are high caloric, low nutrient-dense (e.g. butter, cream cheese, full-fat products), and
79 high fat foods even when there is no hunger or bodily demand for food [25,26,27]. The effects of stress have
80 been found to be exacerbated in obese ($BMI > 30 \text{ kg/m}^2$) compared to normal weight individuals because the
81 former have higher insulin resistance than the latter and demonstrate significantly higher activation of brain
82 reward regions when exposed to stress [24,28].

83 Recent studies among young adults and university students have found that perceived stress is a serious
84 contributor to low diet quality [29,30]. The majority of these studies have focused on food groups (such as fat
85 intake) as a result of stress, rather than assessing the diet quality (a priori/ a posteriori) [30,31,32]. For example,
86 there is evidence that females (18-29 years old), who report high levels of perceived stress (measured through
87 the 14-item perceived stress scale), consume more fat than non-stressed females as assessed by the Night Eating
88 Questionnaire [30,31,32]. When fruits and vegetables consumption was assessed in women of reproductive age,
89 perceived stress was found to significantly decrease their intake [15,16,33,34,35,36]. Studies that have

90 examined stress and diet have been limited in their approach. Habhab et al. [31] assessed the association
91 between perceived stress and diet in females of reproductive age and found that participants in the high stress
92 group (given unsolvable Sudoku) consumed more fats and sweets (measured through the Emotional Eating
93 subscale) than individuals in the low stress group (given easy Sudoku). However, the sample size was small (40
94 participants), baseline hunger status was not measured, and the assignment of participants to low or high stress
95 groups might have by chance assigned stressed individuals to the high stress group. In a study by Barrington et
96 al. [37], higher levels of perceived stress were associated with higher fast food consumption in young women.
97 However, the study used non validated single item scale to measure fast food intake.

98 **In summary, the picture regarding the association between stress and diet in women of reproductive age**
99 **remains unclear. This has gained attention recently, especially that diet-related diseases have been trending over**
100 **the past few years among these women and studying the factors that might affect diet (such as stress) became**
101 **crucial. To our knowledge, this is the first review of the association between stress and dietary patterns/quality**
102 **specifically in women of reproductive age.** The aim of this systematic review is to critically appraise the current
103 literature and identify whether women who exhibit higher levels of stress have a poorer diet pattern/quality than
104 women who exhibit lower levels of stress.

105

106 **2. Methods**

107 The Meta-analysis of Observational Studies in Epidemiology (MOOSE) was used to guide this systematic
108 review [38]. The association between psychological stress and diet quality was examined using the PEO
109 (Population, Exposure, and Outcome) model: Population (women aged 18-49 years old), Exposure
110 (Psychological Stress), Outcome (Diet Quality/Patterns of women of reproductive age).

111

112 **2.1 Search Strategy**

113 A literature search was conducted in December 2019 in Medline complete, CINAHL Complete, Scopus,
114 Cochrane Library, Web of Science, and Sciencedirect. These databases were searched using appropriate key
115 words and index terms where the PEO (Population, Exposure, and Outcome) model framed the search process
116 **(Table 1 in Appendix 1).** The key words were then combined by the EBSCO host operator AND/OR. The
117 databases search was limited to human studies and English language articles published between 2000 and 2019.
118 The search strategy (Title/Abstract) is demonstrated in **Appendix 1.**

119 Alongside title and abstract searching, Medical subject headings (MeSH) were used when searching
120 MEDLINE and CINAHL subject headings when searching CINAHL. The key terms used were: “psychological
121 stress” AND “Diet”. Additionally, reference lists were checked, and authors of unpublished papers were
122 contacted by email.

123

124 2.2 Selection of Studies

125 The reviewer (KK) screened the full texts of all potentially relevant papers, including those over which
126 there was doubt, with excluded articles also reviewed by the second reviewer (FT) to ensure that studies are not
127 erroneously excluded. Any disagreements were resolved by discussion, or arbitrated if necessary, by a third
128 reviewer (VH). Similarly, if eligibility was unclear, this was discussed across the wider team (KK, FT, and VH).

129

130 2.3 Inclusion and Exclusion Criteria

131 Studies were included in the review if they: i) enrolled healthy women aged 18-49 years old, ii) measured
132 psychological stress (subjective and/or objective) as an exposure in combination with diet, iii) comprised
133 **observational** quantitative studies looking at the association between stress and diet quality, iv) were in **English**
134 **language**. Due to the limited resources available, it was not possible to translate non-English papers.

135 For studies in which the sample’s age range may in part be below or over the specified age range for this
136 review, they were included if the mean age of the sample was between the age range of 18-49 years.

137 Articles were excluded if they: i) used qualitative methods, ii) enrolled exclusively men or participants
138 with mean age outside the age range of 18-49 years old; iii) did not report stress data in a format that could be
139 extracted; iv) comprised study sample with health conditions that may confound the diet stress relationship (e.g.
140 depression, mental disorders, heart disease, diabetes, cancer, coeliac disease, eating disorders). Abstracts and
141 unpublished studies were not included in this systematic review.

142

143 2.4 Data Extraction

144 Data extraction and coding stages of the review were completed by the first reviewer (KK) using
145 structured data extraction forms. The following information was extracted from the manuscripts: first author,
146 year of publication, location, study design, number of subjects, period of enrolment and follow-up, age, the
147 exposure (self-reported stress measured via validated stress scales and/or via biological marker (e.g. cortisol

148 levels in blood, hair or saliva). A proportion of the extracted data (30%) was checked for accuracy by second
149 reviewer (FT).

150 For the purpose of meta-analysis, a dataset containing the 7 studies [39,40,41,42,43,44,45] that initially
151 qualified for meta-analysis was built. Ferranti et al. [10] was not among these studies as it did not report any
152 effect size and hence should not be qualified for meta-analysis. The dataset was developed with the help of
153 reviewer (OA) and included the following information from the studies: effect size, number of participants, first
154 author surname, and year of publication. When only β coefficient was reported in any study, a proper
155 conversion was carried out to transform β coefficient to correlation coefficient “r”. This was undertaken using
156 the formula of imputing r value from β [46]: $r = 0.98 \beta + 0.05 \lambda$ (restricted only to linear models and β values
157 between ± 0.5), where λ is an indicator variable that equals 1 when β is nonnegative and 0 when β is negative
158 [46]. In the study by Richardson et al. [43]: $r = 0.98 (-0.18) + 0.05 (0) = -0.1764$. The β coefficient in Isasi et al.
159 [42] is not within the exact range (± 0.5), however due to the large sample size in the study and the proximity of
160 its β coefficient value to the range in the formula of imputing r from β , the formula was applied as follows: $r =$
161 $0.98 (-0.61) + 0.05 (0) = -0.5978$. The formula was not applied to Valipour et al. [44] as it is based on
162 categorical dependent variable model, so this study was also excluded from the meta-analysis.

163

164 2.4.1 Study outcomes

165 Study outcomes included: dietary components (e.g. fat intake, alcohol intake, healthy versus unhealthy
166 diet patterns) or adherence to diet indices (e.g. Alternate Healthy Eating Index (AHEI), the Dietary Approaches
167 to Stopping Hypertension (DASH), and the Mediterranean Diet Score (MDS)).

168

169 2.5 Quality Evaluation

170 The first and second reviewers (KK, FT) assessed bias in all eligible studies using the Risk of Bias in
171 Non-randomised Studies [47], which is recommended by the Cochrane Handbook of Systematic Reviews of
172 Interventions [48]. The bias domains included in the quality assessments were bias due to confounding, bias in
173 selection of participants, bias in classification of interventions, bias due to deviations from intended
174 interventions, bias due to missing data, bias in measurement of outcome, bias in selection of the reported results.
175 Any conflicting opinion of quality of studies was discussed with the third reviewer (VH).

176

177 2.6 Meta-analysis

178 Meta-analysis was performed based on the Cochrane Handbook for Systematic Reviews of
179 Interventions and Borenstein book on meta-analysis [49,50]. Fisher's z transformation of correlation was used
180 as a summary measure of the association between diet quality and stress, whereby correlation coefficients were
181 converted to Fisher's z scale. Due to heterogeneity of the studies, particularly with respect to studies'
182 participants and the methods of measuring the exposure and the outcome, a random effect model has been
183 applied for the meta-analysis. Higgin's & Thompson's I^2 and Cochran's Q measures were used to assess the
184 between-study heterogeneity [50]. Outliers and influential studies were detected by identifying any study with a
185 confidence interval that did not overlap with the confidence interval of the pooled effect through Baujat plot
186 [49]. Publication bias was assessed through a Funnel plot. Sensitivity analysis was performed by applying trim
187 and fill method [49,50]. Following the Cochrane Handbook recommendations, a risk-of-bias assessment was
188 performed for all included studies by creating a "weighted bar" which plots the distribution of risk-of-bias
189 judgements within each bias domain. The figure was formatted according to the risk-of-bias assessment tool
190 (ROBINS-I).

191

192 3. Results

193 The databases identified 139,552 hits; only 471 had a relevant title (Figure 1; (MOOSE Checklist in
194 Appendix 2). The titles and abstracts of these articles were screened further and 382 were deemed not relevant
195 which yielded 89 articles for full-text screening. A further 65 studies were subsequently excluded as they did
196 not meet the criteria. Three studies were eliminated after quality assessment for the following reasons: one
197 study did not have a methods section [51] and two studies measured the emotional/psychological domain of
198 eating as an outcome (disordered eating/emotional eating) [52,53]. A total of 24 studies were included in the
199 review: 8 studies on diet quality (measured the adherence to specific dietary indices as outcome) and 16 studies
200 on food intake and frequency of consumption which reported consumption of different food components and
201 nutrients as proxy measure for dietary patterns (Tables 2, 3, and 4 in Appendices 3,4 and 5 respectively).

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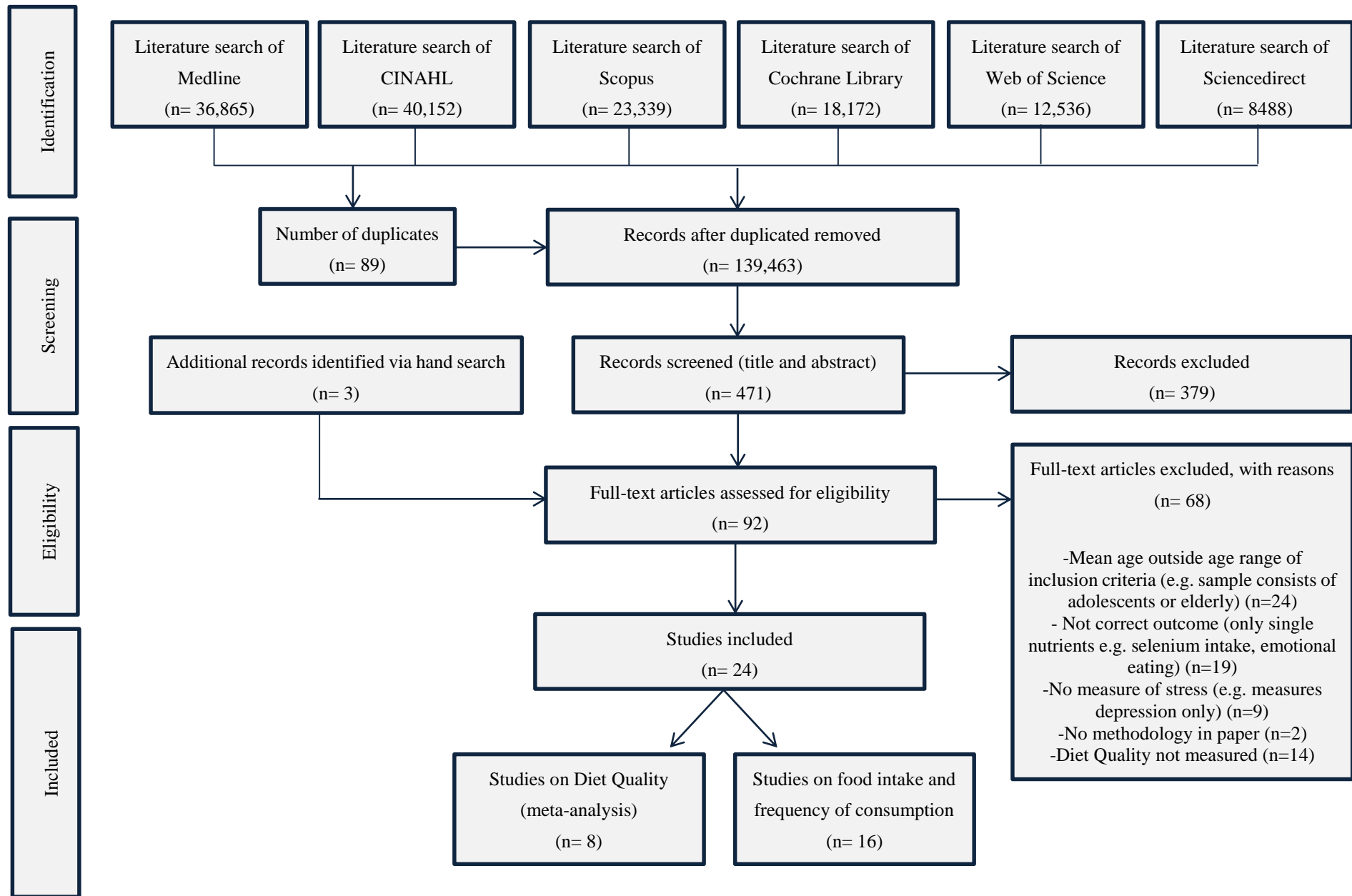


Figure 1. Meta-analysis of Observational Studies in Epidemiology (MOOSE) flow chart

228 3.1 Characteristics of Included Studies

229 Two out of the eight studies that assessed diet quality were longitudinal cohort studies: [10] included 5
230 years of follow-up (n = 429), while [42] followed participants for 9 months (n = 3141) (Table 2). Both studies
231 investigated psychological stress via the Perceived Stress Scale (PSS) at baseline; however, diet quality was
232 investigated through different methods: [10] used food frequency questionnaire at baseline while [42] used two
233 24-hour dietary recalls. The other six studies were cross-sectional, published between 2011 and 2017, and
234 included a total of 3,982 participants [39, 40,41,43,44,45]. Only two out of the eight studies were conducted
235 outside of the USA [39,44]. Two studies included pregnant women of reproductive age who fall in the age range
236 19-49 years old [40,41]. Four studies recruited females only (18-45 years old) [40,41,43,45] while the other four
237 recruited both males and females (16-74 years old) [10,39,42,44].

238 The 16 studies on food intake and frequency of consumption did not assess diet quality, but instead
239 measured the different food components and nutrients. As a result, the studies were very heterogeneous. Studies
240 were all of a cross sectional design and published between 2000 and 2018. Six studies were conducted in USA,
241 two in UK, and the remaining eight were conducted in other countries. Two studies took place in more than one
242 country: Mikolajczyk et al. [34] was done in three European countries (Germany, Poland, Bulgaria) and Hinote
243 et al. [33] was done in eight post-Soviet republics. In only two studies, participants were 100% females; the rest
244 had both males and females with more than half of the participants were females in all of these studies. One
245 study did not specify the percentage of females in its sample [35]. Mean age of participants was between 18.9
246 and 43.9 years and the number of female participants ranged from 52 to 10,454 per study.

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248 3.2 Findings of the Studies

249 In four of the eight studies on diet quality, stress was not associated with diet quality [10,39,43,44], while
250 in another three studies; stress was significantly associated with poorer diet quality [42,40,41] (Table 3).
251 Interestingly, one study found that stress was significantly associated with lower diet quality in breakfast
252 skippers only while no association was found in breakfast eaters [45].

253 The three studies that reported β coefficients indicated mixed results; two found no association [10,39] and
254 one found poorer diet quality when individuals were stressed [42]. Studies that reported correlation coefficient
255 “r” found negative association between stress and diet quality [40,41], no association [39], and mixed results
256 (negative association in breakfast skippers/no association in breakfast eaters) [45] as shown in Table 3.

257 The outcomes of the 16 studies on food intake and frequency of consumption were very heterogeneous and
258 thus it was not possible to perform a meta-analysis (Table 4). All studies that assessed fat intake found that
259 perceived stress was significantly associated with increased fat consumption [1,36,54,55,56]. Only Hwang et al.
260 [57] reported a significant decrease in fat intake, along with decreased intake of energy, carbohydrates, protein,
261 calcium, vitamin A, zinc, thiamine, riboflavin, and folate, as a result of high stress ($p < 0.05$). The intake of fruits,
262 vegetables, and grains was found to be significantly lower in individuals with higher stress ($p < 0.02$)
263 [15,16,33,34,35,36,37]. Some studies assessed the intake of fast food, sweets, snacks, and energy drinks and
264 found a direct association between these foods and perceived stress ($p < 0.05$) [15,34,37,58,59]. The
265 consumption of meat and meat alternatives was measured in three studies and was inversely correlated with
266 stress ($p < 0.05$) [16,33,35]. Mixed results were found in two studies that assessed alcohol intake: Gonzalez et al.
267 [60] found that perceived stress was significantly associated with greater consumption of alcohol ($p < 0.05$)
268 whereas Ng et al. [55] found no significant association ($p = 0.4$).

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270 3.3 Meta-analysis

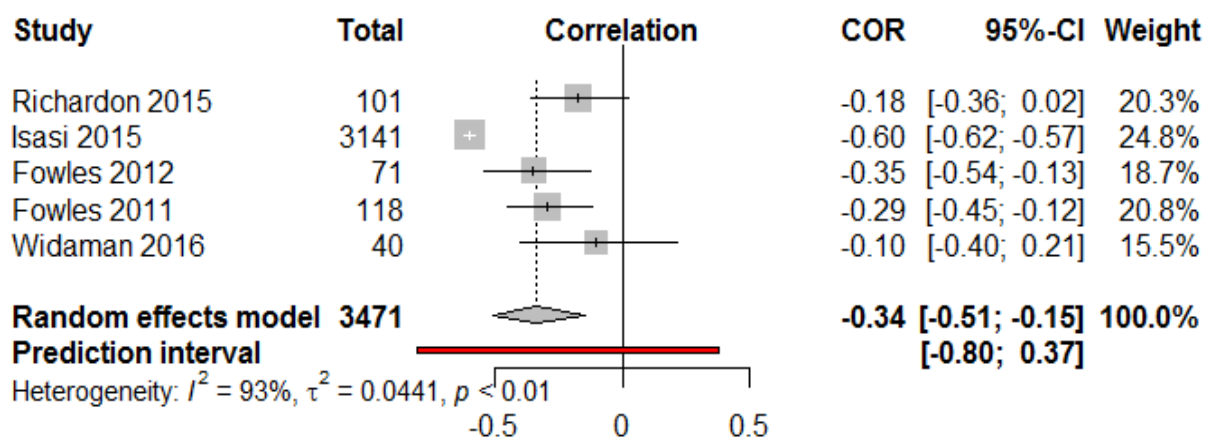
271 Using the aforementioned methods for meta-analysis, 6 studies on diet quality were eligible for the
272 meta-analysis [39,40,41,42,43,45].

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274 3.3.1 Assessment of Heterogeneity

275 Outliers and influential analysis identified one outlier study [39]. Before removing this study from the
276 analysis, the pooled effect was $r = -0.28$ (95% CI [-0.45; -0.08], p value < 0.01). The overall effect size estimate
277 (pooled correlation) was recalculated after removing this study and revealed a medium, negative, and very
278 significant correlation ($r = -0.34$, 95% CI [-0.51; -0.15], p value < 0.001) with 95% prediction interval of [-0.80;
279 0.37]. These results (Figure 2) suggest that a higher stress level was associated with poorer diet quality, and vice
280 versa. The I^2 heterogeneity measure in this analysis was substantial (93%), indicating significant variability
281 across the studies (heterogeneity) and supporting the use of a random-effects model. Additionally, this
282 conclusion was supported by Cochran's Q test of heterogeneity which showed a very significant P value
283 (< 0.0001).

284



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286

287 **Figure 2.** Association between stress and diet quality (five studies based on correlation coefficient “r” and

288

converted β coefficients to “r”).

289

290 Given the broad prediction interval in figure 2, which stretched well above zero, we cannot be 100%

291 confident that the negative correlation between stress and diet quality found in this meta-analysis will be robust

292 in every context.

293

294 3.3.2 Publication Bias

295 The funnel plot created was asymmetrical (Appendix 6). The asymmetry was mainly driven by one small

296 size study [45] that has a large standard error and was shown in the bottom-right corner of the plot. This

297 resembles a publication bias. Although this might occur due to chance, it might have also been comprised as a

298 result of heterogeneity. The number of studies included in the meta-analysis was too small (5 studies) to test for

299 significance of funnel plot asymmetry.

300

301 3.3.3 Sensitivity analysis

302 Trim-and-fill procedure identified three studies (Appendix 7) and assumed that initial results were

303 underestimated due to publication bias. The true effect might be $r = -0.57$ (95% CI [-0.75; -0.31], p value < 0.01)

304 rather than $r = -0.34$. Due to the assumed missing studies (small size studies reporting large effect sizes) and the

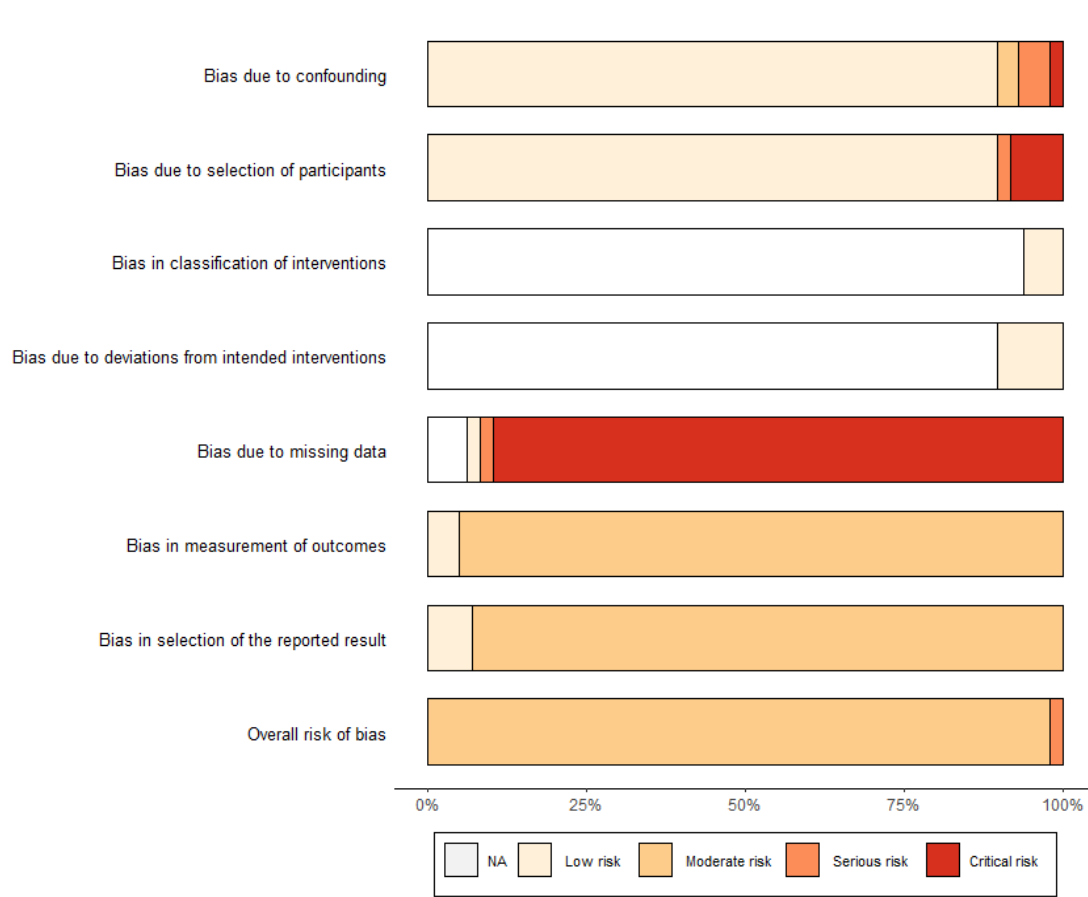
305 small number of studies in this meta-analysis, the result of sensitivity analysis ($r = -0.57$) is not considered a

306 more valid estimate of the pooled correlation.

307

308 **3.4 Quality assessment**

309 Using “robvis” package, a weighed bar plot of the distribution of risk-of-bias judgments within each bias
310 domain (Figure 3) was generated to visualize the quality assessment performed for the 24 studies that were
311 included in this systematic review.



312 **Figure 3. Weighed bar plot of the distribution of risk-of-bias judgments within each bias domain**

313
314
315 Figure 3 shows that most studies scored moderate with regards to bias in measurement of outcomes,
316 selection of the reported results, and the overall risk of bias. More than 75% of studies had a critical risk of bias
317 due to missing data. When it came to the bias due to confounding and selection of participants, around 90% of
318 studies had a low risk, and most studies scored not available (NA) risk with regards to bias
319 of interventions and deviations from intended interventions.

320
321 **3.5 Recruitment Procedure**

322 Recruitment procedures were very different among studies. In the eight studies on diet quality, three used
323 data from participants enrolled in large cohorts from previous projects [10,42,44] while Fowles et al. [40,41]
324 recruited low income pregnant women in clinics using recruitment cards and forms (Table 1). The staff of a
325 nutrition program helped Richardson et al. [43] identify women eligible for the study and the study staff asked
326 them for their interest. Widaman et al. [45] recruited participants through advertisements on local newspapers,
327 websites, and posted flyers while university students were recruited by distributing questionnaires during
328 lectures [39]. Ethical approval was granted in seven studies and one study [42] did not give information
329 regarding the ethical approval of the study.

330 Among the 16 studies of food intake and frequency of consumption, five studies used previous data of
331 large cohort studies [33,35,37,55,57]. Eight studies recruited participants who were students through posters,
332 flyers, or classroom visits at different university campuses [1,15,16,34,54,58,59,60]. Participants of the three
333 remaining studies were recruited differently; through community organizations [36,61] or from staff of a large
334 department store [55]. Three studies did not provide information regarding ethical approval [33,55,56], whereas
335 all other thirteen studies mentioned that ethical approval was given prior to conducting the studies.

336

337 3.6 Exposure: Perceived Stress

338 In four of the eight studies that assessed diet quality [10,39,42,43], the Perceived Stress Scale (PSS) was
339 used as a measure of psychological stress, whereas the other four studies used different scales such as: the
340 General Health Questionnaire [44], the Prenatal Psychosocial Profile stress sub-scale [40,41], and Wheaton
341 Chronic Stress Inventory [45]. None of the studies used biomarkers of psychological stress (e.g. salivary
342 cortisol) as a measure of the exposure.

343 All 16 studies that assessed food intake and frequency of consumption measured stress through
344 self-reported measures: 10 studies used the Perceived Stress Scale [1,15,34,37,54,55,56,58,59,61] and the six
345 remaining studies used different other scales (Table 3).

346

347 3.7 Dietary Assessment

348 A variety of dietary instruments were used to assess habitual dietary intake in the eight studies that
349 assessed diet quality. Three studies [10,39,44] used different Food Frequency Questionnaires (FFQs) to assess
350 dietary intake (Table 1). The other five studies used 24-hour dietary recalls for either: three days [40,41,45], two
351 days [42], or one-to-two days [43].

352 With respect to diet quality, all studies used the a priori defined method (using diet indices) to derive the
353 diet quality. A variety of diet quality indices were included: i) Alternate Healthy Eating Index [10,42], ii)
354 Healthy Eating Index [43,45], iii) The Dietary Approach to Stop Hypertension (DASH) Diet Index [10,44], iv)
355 Dietary Quality Index- Pregnancy [40,41], v) Dietary Guideline Adherence Index [39]. Interestingly, only one
356 study combined three diet quality indices to measure diet quality [10], while all other studies used only one
357 index. No study was found to assess diet quality via a posteriori approach i.e. to define diet patterns with
358 statistical methods such as Factor Analysis.

359 There was also diversity in the tools used to assess food intake and frequency of consumption. Four of the
360 16 studies used food frequency questionnaires [15,16,34,35], three used dietary recalls [36,56,57], another three
361 used Block fat screener [1,54,55], two used alcohol intake frequency questions [55,60], one used Block sodium
362 screener [54], and one used weighed food records [61]. The remaining studies used different questions about
363 food and beverages consumption (Table 1).

364

365 3.8 Confounding Factors:

366 Table 1 indicates that seven of the eight studies of diet quality identified and corrected for socioeconomic
367 status of participants as confounding factor. The exception was the study by Widaman et al. [45]. One study
368 identified only age and educational level as means of socioeconomic status [40]. Three out of the eight studies
369 did not assess the physical activity level of participants [40,41,43]. The anthropometric measures of participants
370 were measured in all eight studies, either through BMI [10,39,40,41,43,45] or both Waist Circumference and
371 BMI [42,44]. Smoking status was reported in three studies [40,41,44], marital status in five [10,40,41,43,44],
372 and energy intake in three [10,42,45].

373 In the 16 studies of food intake and frequency of consumption, two studies did not identify or correct for
374 confounding factors [15,34]. All remaining studies identified socioeconomic status and demographic
375 information of participants. Only five studies measured physical activity among participants [16,35,37,55,57].
376 BMI was reported in seven studies as a measure of adiposity [16,35,37,54,56,58,61] and only one study
377 reported both waist circumference and BMI [57].

378

Author, Year	Country	Age and Number of Participants	Study Design	Participants in Study	Dietary Assessment Tool	Confounding Factors Identified
<i>8 studies on Diet Quality</i>						
<i>Richardson et al. 2015 [43]</i>	USA	18-44 y, N=101	CS	Women who had a child up to age 5	24-hour Dietary recalls	SES, AM
<i>Ferranti et al. 2013 [10]</i>	USA	Mean age 48 y, N=433	LG (5 y follow up)	University and health center employees	FFQ	SES, PA, AM,
<i>Isasi et al. 2015 [42]</i>	USA	18-74 y, N=3,141	LG (9 m follow up)	Hispanic/Latino males and females	24-hour Dietary recalls	SES, PA, AM
<i>El Ansari et al. 2015 [39]</i>	Egypt	16-30 y, N=1,483	CS	Undergraduate students males and females	FFQ	SES, PA, AM
<i>Valipour et al. 2017 [44]</i>	Iran	28-45 years old, N= 2,134	CS	General Adults	FFQ	SES, PA, AM
<i>Fowles et al. 2012 [41]</i>	USA	Mean age 24.7 y, N=71	CS	Low income pregnant women	24-hour Dietary recalls	SES, AM
<i>Fowles et al. 2011 [40]</i>	USA	Mean age 25 y, N=118	CS	Low income pregnant women	24-hour Dietary recalls	SES, AM
<i>Widaman et al. 2016 [45]</i>	USA	Mean Age 25.1, N=35 (BS) Mean Age 24.1, N= 40 (BE)	CS	Female habitual breakfast eaters and breakfast skippers	24-hour Dietary recalls	PA, AM
<i>16 studies on Food Intake and Frequency of Consumption</i>						
<i>Vidal et al. 2018 [1]</i>	Peru	Mean Age: 19 y, N= 272	CS	Undergraduate students	Block fat screener	SES
<i>Nastaskin et al. 2015 [54]</i>	Canada	Mean age: 20 y, N=113	CS	Students	Block fat screener/ Block sodium screener	SES, AM
<i>Pettit et al. 2011 [59]</i>	USA	18-24 y, N=78	CS	Undergraduate students	Energy drink intake questions	SES
<i>Mikolajczyk et al. 2009 [34]</i>	Germany, Poland, Bulgaria	Mean age: 20 y, N=1,201	CS	Fist year undergraduate students	FFQ	-
<i>Errisuriz et al. 2016 [58]</i>	USA	Mean age: 18.9 y, N=433	CS	Freshman students	Food and beverage frequency questions	SES, AM
<i>El Ansari et al. 2014 [15]</i>	UK	Mean age: 24.9 y, N=2,699	CS	Students	FFQ	-
<i>Ng et al. 2003 [55]</i>	USA	Mean age: 40 y, N=6,620	CS	Working adults	Block Fat Screener/ Alcohol frequency questions	SES, PA
<i>Barrington et al. 2012 [37]</i>	USA	18-65 y, N=357	CS	Working adults	Single-item question for fast food intake/ 5-A-Day fruit & vegetable assessment tool	SES, PA, AM
<i>Grossniklaus et al. 2010 [61]</i>	USA	Mean age: 41.3 y, N=64	CS	Working adults	3-day WFR	SES, AM
<i>Papier et al. 2015 [16]</i>	Australia	Mean Age 21.2 y, N=397	CS	Students	FFQ	SES, PA, AM
<i>Roohafza et al. 2013 [35]</i>	Iran	Mean age: 38.4 - 39.5 y, N=9,549	CS	General adults	FFQ	SES, PA, AM
<i>Gonzalez et al. 2013 [60]</i>	Puerto Rico	21-30 y, N=186	CS	First and second year students	Alcohol frequency questions	SES
<i>Tseng et al. 2011 [36]</i>	USA	Mean age 43.9 y, N= 426	CS	Premenopausal women	48- hour Dietary recalls	SES
<i>Hinote et al. 2009 [33]</i>	8 post-Soviet republics	>18 y, N=10,454	CS	General adults	Questions about frequency of consumption	SES
<i>Hwang et al. 2010 [57]</i>	Korea	Mean age: 23.7 y, N=570	CS	Vietnamese female marriage immigrants	1-day Dietary recalls	SES, PA, AM
<i>Wardle et al. 2000 [56]</i>	UK	Mean Age: 36.29 y, N=58	CS	Staff of a store	24-hour Dietary recalls	SES, AM

Table 2. Characteristics extracted from the 24 included studies: BS (Breakfast skippers), BE (Breakfast eaters), CS (Cross-Sectional), LG (Longitudinal), y (years), m (months), FFQ (Food Frequency Questionnaire), WFR (Weigh food record), SES (Socioeconomic status), PA (Physical Activity), AM (Anthropometric measures), - (not reported).

Author, Year	Stress Assessment Tool	Diet Quality Index	Association between Stress and Diet Quality	β coefficient, r, or OR
<i>Richardson et al. 2015 [43]</i>	- 14-item Perceived Stress Scale	- Healthy Eating Index 2010	<=>	$\beta = -0.18$ (S.E 0.10, $p=0.08$)
<i>Ferranti et al. 2013 [10]</i>	- 14-item Perceived Stress Scale - Beck Depression Inventory II	- Alternate Healthy Eating Index - Mediterranean Diet Index - Dietary Approach to Stop Hypertension Index	<=>	Not reported
<i>Isasi et al. 2015 [42]</i>	- 10-item Perceived Stress Scale - 8-item Chronic stress burden	- Alternate Healthy Eating Index 2010	↓	$\beta = -0.61$ (-1.18 to -0.03)
<i>El Ansari et al. 2015 [39]</i>	- 4-item Perceived Stress Scale	- Dietary Guideline Adherence Index	<=>	$r = 0.00$, $p=0.98$ $\beta = 0.00$ (-0.13 to 0.13)
<i>Valipour et al. 2017 [44]</i>	- 12-item General Health Questionnaire	- Dietary Approach to Stop Hypertension Index	<=>	OR: 1.02 (0.78-1.33)
<i>Fowles et al. 2012 [41]</i>	- Edinburgh Postnatal Depression Scale - Prenatal Psychosocial Profile-stress subscale	- Dietary Quality Index- Pregnancy	↓	$r = -0.35$, p is not reported
<i>Fowles et al. 2011 [40]</i>	- Edinburgh Postnatal Depression Scale - Prenatal Psychosocial Profile-stress subscale	- Dietary Quality Index- Pregnancy	↓	$r = -0.293$, $p < 0.01$
<i>Widaman et al. 2016 [45]</i>	- Wheaton Chronic Stress Inventory	- Healthy Eating Index 2010	↓ in breakfast skippers <=> in breakfast eaters	Empty calories ($r = -0.392$, $p = 0.027$) Empty calories ($r = -0.104$, $p = 0.53$)

Table 3. Data values extracted from the included eight studies on Diet Quality: β (Beta coefficients), r (correlation coefficient), OR (Odd Ratio), \uparrow (increase), \downarrow (decrease), <=> (no association)

Author, Year	Stress Assessment Tool	Association between Stress and the measured Food intake and frequency of consumption	Values
Vidal et al. 2018 [1]	14-item Perceived Stress Scale	↑ Fat intake	p=0.005
Nastaskin et al. 2015 [54]	14-item Perceived Stress Scale	↑ Fat intake ↑ Sodium intake	r= .35, p<0.01 r= .23, p=0.07
Petit et al. 2011 [59]	14-item Perceived Stress Scale	↑ Energy Drink intake	r= .235, p<0.01
Mikolajczyk et al. 2009 [34]	14-item Perceived Stress Scale	↑ Sweets, cookies, snacks, fast food ↓ Fruits/vegetables	p=0.03 p<0.01
Errisuriz et al. 2016 [58]	Perceived stress single item scale (0-10)	↑ Soda, coffee, energy drink, salty snack, sweet snack, frozen food, and fast food consumption	p<0.05
El Ansari et al. 2014 [15]	4-item Perceived Stress Scale	↑ Sweets, cookies, snacks, fast food ↓ Fruits and vegetables	P=0.017 P=0.002
Ng et al. 2003 [55]	4-item Perceived Stress Scale	↑ High Fat diet <=> Alcohol intake	p<0.01 p=0.4
Barrington et al. 2012 [37]	10-item Perceived Stress Scale	↑ Fast food intake ↓ Fruits and vegetables intake	z = 3.00, P= .003 z = -3.01, P= .003
Grossniklaus et al. 2010 [61]	Perceived Stress Scale	<=> food and beverage intake	p>0.05
Papier et al. 2015 [16]	Depression Anxiety Stress Scale (DASS)	↑ processed foods ↓ meat alternatives ↓ vegetables and fruits	p<0.01 p<0.05 p<0.01
Roohafza et al. 2013 [35]	-A12-item General Health Questionnaire (GHQ-12)	↑ Saturated oils ↓ Unsaturated oils ↓ Fruits ↓ Vegetables ↓ Meat ↓ dairy products	p<0.01 p<0.01 p<0.01 p=0.02 p=0.03 p<0.01
Gonzalez et al. 2013 [60]	Cognitivist Systemic Model Academic Stress scale	↑ Alcohol intake	p<0.05
Tseng et al. 2011 [36]	Migration–Acculturation Stressor Scale	↑ Energy density ↑ % energy from fat ↓ total grams of grains ↓ Overall grain intake	-(β= 0.002, p=0.04) -(β=0.06, p= 0.05) -(β=-11.3, p<0.0001) -(β=-0.18, p=0.03)
Hinote et al. 2009 [33]	12-item distress scale	↓ Meat, fish, vegetables, fruits, animal fat	p<0.001
Hwang et al. 2010 [57]	Psychological Well-Being Index	↓ energy intake ↓ carbohydrates ↓ protein ↓ fat ↓ calcium ↓ vitamin A ↓ zinc ↓ thiamine ↓ riboflavin ↓ folate	-p=0.011 -p=0.004 -p=0.021 -p=0.021 -p=0.042 -p=0.039 -p=0.005 -p=0.006 -p=0.013 -p=0.004
Wardle et al. 2000 [56]	10-item Perceived Stress Scale	↑ energy intake, ↑ saturated fats intake, ↑ fat intake	p<0.05, p<0.01, p<0.05

Table 4. Data values extracted from the included studies on food intake and frequency of consumption: ↑ (increase), ↓ (decrease), <=> (no association)

387 **4. Discussion**

388 Our findings suggest that stress appears to impact diet negatively regardless of the various dietary
389 outcomes measured among studies. Stress decreased diet quality and contributed to unhealthy dietary patterns,
390 particularly high fat, fast food, sweets, and energy dense foods. In contrast stress lowered the intake of fruits,
391 vegetables, fish and unsaturated oils.

392 The mixed results, especially in the eight studies on diet quality, highlights the disparity of evidence that
393 exists in the literature regarding the association between stress and diet quality for the general population. In
394 other populations, such as adolescents, perceived stress has been associated with poorer diet quality, measured
395 through Diet Quality Index for Adolescents (DQI-A) ($\beta = -0.04$, $p < 0.01$), [62]. An inverse association has been
396 also reported in a systematic review with regards to mental health (including stress) and diet quality in children
397 and adolescents [63] while Sims et al. [53] found no association between perceived stress and diet quality
398 among female African American adults.

399 In almost all 16 studies on food intake and frequency of consumption included in our review, higher
400 perceived stress was associated with an unhealthy eating pattern, characterised by increased consumption of
401 sweets, fast food, fats and lower consumption of fruits and vegetables. This is in line with studies of other
402 populations. Increased stress in female undergraduate students and peri-menopausal women has been linked
403 with greater consumption of high calorie foods [64,65]. Similarly, O'connor et al. [32] showed that daily stress
404 was associated with a higher intake of high fat/sugar food and a reduced intake of fruits and vegetables in
405 women. Wichianson et al. [30] found that stress was associated with unhealthy night-eating syndrome (NES) in
406 a sample of 95 college students ($\beta = 0.259$, $p < 0.05$). Interestingly, one of the 16 studies on food intake and
407 frequency of consumption found that stress was linked with decreased fat intake (along with all macro- and
408 micro-nutrients) [57]. This contradicts the majority of studies in the field with only Torress et al. [23] finding an
409 inverse association between stress and fat. Torres et al. [23] assessed daily record of stress and diet among male
410 and female students and found that participants consumed less food and dietary fat when they were stressed.
411 These conflicting results indicate that there might be inter-individual variation in response to stress.

412 The differences in results presented in Tables 2 and 3 must be interpreted with caution due to the
413 challenges in assessing dietary intake. The eight studies on diet quality used different methods to collect dietary
414 data: five studies used 24-hour recalls [42,40,41,43,45] and mainly found negative association between stress
415 and diet quality, while three studies [10,39,44] used food frequency questionnaires and found no association
416 between stress and diet quality, which might explain the variance in the findings. Similarly, the 16 studies on

417 food intake and frequency of consumption used food frequency questionnaires [15,16,34,35], dietary recalls
418 [36,56,57], block fat screener [1,54,55], and other different tools to assess dietary intake and found that stress
419 was associated with the intake of unhealthy diet (higher fat, sweets, fast food, salt; lower fruits, vegetables,
420 whole grains, and seafood). Although the use of food frequency questionnaires, 24-hour dietary recalls, and the
421 above-mentioned tools in nutrition epidemiology is quite common, measurement errors caused by
422 self-reporting (under-reporting or over-reporting) of food intake occur leading to the manipulation of the
423 expected associations. Furthermore, these dietary assessment methods might not be ideal for investigating the
424 response to perceived stress; different methods such as ecologic momentary assessment, which aims to
425 minimise recall bias, might be better in reporting dietary/behavioural responses to stress that take place in real
426 time [42,66].

427 Disparities exist between the two groups of studies in our review. Most of the 16 studies on food intake
428 and frequency of consumption indicate that stress increases energy intake and food consumption
429 [15,36,56,57,58,59,60]. In contrast, the majority of the eight studies on diet quality found no association
430 between diet quality, which depends on food consumption, and stress. This can be explained mainly due to the
431 diet quality indices used in the studies. Of the three studies that measured diet quality through the Healthy
432 Eating Index (HEI) (including the Alternative HEI), two found no association between stress and diet quality
433 [10,43] and one found an inverse association [42]. However, out of the twelve scoring components of the HEI,
434 nine will be scored higher if the intake of certain foods is higher which means that participants might have a
435 higher energy and food consumption than they need and still score high on the HEI and have a higher diet
436 quality. Moreover, the mixed findings could be related to the socioeconomic status of the participants as low
437 socioeconomic populations tend to be more stressed than socially advantaged populations. A previous
438 meta-analysis found that socioeconomically disadvantaged individuals had increased odds of being stressed and
439 depressed (odds ratio = 1.81, $p < 0.001$) [67].

440 Two studies on diet quality were conducted among pregnant women [40,41] and were included in the
441 review since prenatal stress and diet are considered important for the intrauterine environment that affects
442 several developmental outcomes [68,69,70]. The variation in diet quality of women during pregnancy has been
443 associated with health outcomes of the fetus [71,72,73,74,75,76]. Similarly, maternal stress during conception
444 is linked to disease risk and developmental outcomes of the fetus [68,77,78,79,80,81]. More studies looking on
445 diet and stress in this population and in the preconception stage are needed and should be conducted across
446 different countries and with unified methodologies to allow comparison and confirm the stress/diet association.

447

448 4.1 Strengths and Limitations of the Study

449 With diet quality and food intake in women of reproductive age being significant predictors of obesity and
450 complications during pregnancy, the present systematic review adds to the body of knowledge by providing
451 evidence on the role of psychological stress in manipulating diet quality. This will help in developing stress
452 reducing strategies and guide future health care. The large sample size of most studies is a major strength of the
453 present review. Another strength is restricting the sample to healthy women where studies with sample that had
454 health conditions such as depression, metabolic diseases, and eating disorders were excluded, because these
455 conditions might manipulate the diet quality and are considered significant confounding factors.

456 However, the 24 studies in the review are very heterogeneous in both participants that they recruited and
457 the methods that they used, making pooling of these results challenging. Most of the eight studies on diet quality
458 were conducted in USA and only two studies were conducted in the Middle East; no studies were conducted in
459 Europe or Asia. This highlights the importance of conducting similar studies on diet quality among populations
460 with different ethnicity and cultural backgrounds to confirm any possible differences. Another limitation is that
461 in the 24 studies, stress was measured by self-reported stress scales and dietary intake was measured using
462 24-hour recalls, food frequency questionnaires, or other self-reported questionnaires, which could lead to errors
463 during dietary reporting and classification. A study measuring physiological markers of stress (such as serum or
464 salivary cortisol) and biomarkers of dietary intake (such as urinary nitrogen, plasma vitamin C, and serum
465 carotenoids) would provide stronger evidence. Moreover, differences in diet quality indices, dietary outcomes
466 measured, and methodologies between the 24 studies made it difficult to compare the results of the studies. This
467 issue has been highlighted by Mikolajczyk et al. [34] who recommended that research looking on stress and diet
468 should be conducted across diverse population groups and amongst different countries which can enable the use
469 of unified methodology and meaningful comparison of comparable outcomes. At present, it is challenging to
470 compare results derived from studies conducted in single countries due to variation in methodologies and
471 measures of diet and stress. The study design was a major limitation where studies were cross-sectional and
472 longitudinal; hence, no **causation** or definitive conclusions can be drawn about the association between
473 psychological stress and diet. A case-control study could provide more accurate evidence on the relationship
474 between stress and diet. Including studies that are only in English language might be another limitation where
475 evidence from studies published in other languages was not considered. **Moreover, a prospective registration of**
476 **this systematic review (for example on PROSPERO) was not done and this was also considered a limitation of**

477 **this paper.** The authors also declare that a thorough review/search of unpublished literature was not done,
478 however the authors of unpublished papers were contacted and there were only 3 non-English abstracts found
479 during the literature search.

480

481 5. Conclusions

482 Studies exploring the association between stress and diet in women of reproductive age reported mixed
483 results. This review adds to the current knowledge by highlighting the inverse association between stress and
484 diet. **However, there was substantial heterogeneity in both methods and outcomes, which made it difficult to**
485 **pool the study results and draw a solid conclusion about the association between stress and diet quality/patterns.**

486 Studies of rigorous design and robust methodology are needed to determine the role of stress in manipulating
487 the dietary patterns/quality of women of reproductive age. In particular, it is crucial to conduct studies in
488 different countries, with larger number of participants, and with well-designed, unified and standardised
489 methodologies.

490 **Although some studies reported a significant association between stress and diet, this systematic review**
491 **cannot determine causation of this association.** At the clinical level, results from this systematic review, that
492 showed inverse association between stress and healthy dietary patterns/quality in women of reproductive age,
493 might be useful to implement stress coping strategies aimed at lowering stress levels and improving the quality
494 of diet, **and vice versa.**

495

496

497 Abbreviations:

498 UK: United Kingdom; PRISMA: The Preferred Reporting Items for Systematic reviews and Meta-analysis
499 Approach; PEO: Population, Exposure, and Outcome; AHEI: Alternate Healthy Eating Index; DASH: Dietary
500 Approach to Stopping Hypertension; MDS: Mediterranean Diet Score; CASP: Critical Appraisal Skills
501 Programme; PSS: Perceived Stress Scale; USA: United States of America; CI: Confidence Intervals; FFQ:
502 Food Frequency Questionnaires; BMI: Body Mass Index; CS: Cross sectional; LG; Longitudinal; SES:
503 Socioeconomic status; BS: Breakfast skippers; BE: Breakfast eaters; y: years; m: months; WFR: Weighed Food
504 Records; PA: Physical activity; AM: Anthropometric measures; OR: Odd ratio; DQIA: Diet Quality Index for
505 Adolescents; HEI: Healthy Eating Index

506

507 **Ethics approval and consent to participate**

508 Not applicable

509

510 **Consent for publication**

511 Not applicable

512

513 **Availability of data and materials**

514 Not applicable

515

516 **Competing interests**

517 The authors declare that they have no competing interests.

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524 K.K., O.A., F.T., and V.H.; interpretation, K.K., F.T., and V.H.; writing—original draft preparation, K.K.;

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698 childhood nutrition and maternal prenatal stress on offspring immune system development and
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82. Diet	"diet* qualit*" or "diet* pattern*" or diet* or nutrition* or food intake* or food N5 consumption* or eating N5 habit* or eating behaviour* or " Mediterranean diet*" or "MDS" or "aMED" or priori or posteriori or Food or "Health* behaviour*" or energy N5 intake* or "nutrition* status" or "health* status" or eat* or appetite or "feeding behaviour*"
Stress	Stress* or anxiet* or anxious* or depress* or Psycholog* or distress* or emotion*
Women of reproductive age	wom#n or "childbearing age*" or "reproductive age*" or female* or premenopausal or "before pregnanc*" or "prior to conception" or "prior to pregnancy" or preconception

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Appendix1: Table 1. Search strategy

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MOOSE Checklist Reporting Criteria	Reported (Yes/No)	Reported on Page No.
Reporting of Background		
Problem definition	Yes	2,3
Hypothesis statement	Yes	4
Description of Study Outcome(s)	Yes	4
Type of exposure or intervention used	Yes	4
Type of study design used	Yes	5
Study population	Yes	5
Reporting of Search		

Strategy		
Qualifications of searchers (eg, librarians and investigators)	Yes	5
Search strategy, including time period included in the synthesis and keywords	Yes	4
Effort to include all available studies, including contact with authors	Yes	5
Databases and registries searched	Yes	4
Search software used, name and version, including special features used (eg, explosion)	Yes	4
Use of hand searching (eg, reference lists of obtained articles)	Yes	5
List of citations located and those excluded, including justification	Yes	8
Method for addressing articles published in languages other than English	Yes	5
Method of handling abstracts and unpublished studies	Yes	5
	Yes	5

Description of any contact with authors		
Reporting of Methods		
Description of relevance or appropriateness of studies assembled for assessing the hypothesis to be tested	Yes	5
Rationale for the selection and coding of data (eg, sound clinical principles or convenience)	Yes	6
Documentation of how data were classified and coded (eg, multiple raters, blinding, and interrater reliability)	Yes	6
Assessment of confounding (eg, comparability of cases and controls in studies where appropriate)	Yes	6
Assessment of study quality, including blinding of quality assessors; stratification or regression on possible predictors of study results	Yes	6
Assessment of heterogeneity	Yes	7
Description of statistical methods (eg, complete description of fixed or random effects models, justification of whether the chosen models account for predictors of study results, dose-response models, or cumulative meta-analysis) in sufficient detail to be replicated	Yes	7
Provision of appropriate tables and graphics	Yes	5,8,11,12,13,16,17,18
Reporting of Results		
Table giving descriptive information for each study included	Yes	16
Results of sensitivity testing (eg, subgroup analysis)	Yes	10
Indication of statistical uncertainty of findings	Yes	9,10

Reporting of Discussion		
Quantitative assessment of bias (eg, publication bias)	Yes	12
Justification for exclusion (eg, exclusion of non-English-language citations)	Yes	21,22
Assessment of quality of included studies	Yes	13
Reporting of Conclusions		
Consideration of alternative explanations for observed results	Yes	22
Generalization of the conclusions (ie, appropriate for the data presented and within the domain of the literature review)	Yes	22
Guidelines for future research	Yes	22
Disclosure of funding source	Yes	23

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Author, Year	Country	Age and Number of Participants	Study Design	Participants in Study	Dietary Assessment Tool	Confounding Factors Identified
8 studies on Diet Quality						
Richardson et al. 2015 [43]	USA	18-44 y, N=101	CS	Women who had a child up to age 5	24-hour Dietary recalls	SES, AM
Ferranti et al. 2013 [10]	USA	Mean age 48 y, N=433	LG (5 y follow up)	Male and female university and health center employees	FFQ	SES, PA, AM,
Isasi et al. 2015 [42]	USA	18-74 y, N=3,141	LG (9 m follow up)	Hispanic/Latino males and females	24-hour Dietary recalls	SES, PA, AM
El Ansari et al. 2015 [39]	Egypt	16-30 y, N=1,483	CS	Undergraduate students males and females	FFQ	SES, PA, AM
Valipour et al. 2017 [44]	Iran	28-45 years old, N= 2,134	CS	General Adults	FFQ	SES, PA, AM
Fowles et al. 2012 [41]	USA	Mean age 24.7 y, N=71	CS	Low income pregnant women	24-hour Dietary recalls	SES, AM
Fowles et al. 2011 [40]	USA	Mean age 25 y, N=118	CS	Low income pregnant women	24-hour Dietary recalls	SES, AM
Widaman et al. 2016 [45]	USA	Mean Age 25.1, N=35 (BS) Mean Age 24.1, N= 40 (BE)	CS	Female habitual breakfast eaters and breakfast skippers	24-hour Dietary recalls	PA, AM
16 studies on Food Intake and Frequency of Consumption						
Vidal et al. 2018 [1]	Peru	Mean Age: 19 y, N= 272	CS	Undergraduate students	Block fat screener	SES
Nastaskin et al. 2015 [54]	Canada	Mean age: 20 y, N=113	CS	Students	Block fat screener/ Block sodium screener	SES, AM
Pettit et al. 2011 [59]	USA	18-24 y, N=78	CS	Undergraduate students	Energy drink intake questions	SES
Mikolajczyk et al. 2009 [34]	Germany, Poland, Bulgaria	Mean age: 20 y, N=1,201	CS	Fist year undergraduate students	FFQ	-
Errisuriz et al. 2016 [58]	USA	Mean age: 18.9 y, N=433	CS	Freshman students	Food and beverage frequency questions	SES, AM
El Ansari et al. 2014 [15]	UK	Mean age: 24.9 y, N=2,699	CS	Students	FFQ	-
Ng et al. 2003 [55]	USA	Mean age: 40 y, N=6,620	CS	Working adults	Block Fat Screener/ Alcohol frequency	SES, PA

					questions	
Barrington et al. 2012 [37]	USA	18-65 y, N=357	CS	Working adults	Single-item question for fast food intake/ 5-A-Day fruit & vegetable assessment tool	SES, PA, AM
Grossniklaus et al. 2010 [61]	USA	Mean age: 41.3 y, N=64	CS	Working adults	3-day WFR	SES, AM
Papier et al. 2015 [16]	Australia	Mean Age 21.2 y, N=397	CS	Students	FFQ	SES, PA, AM
Roohafza et al. 2013 [35]	Iran	Mean age: 38.4 - 39.5 y, N=9,549	CS	General adults	FFQ	SES, PA, AM
Gonzalez et al. 2013 [60]	Puerto Rico	21-30 y, N=186	CS	First and second year students	Alcohol frequency questions	SES
Tseng et al. 2011 [36]	USA	Mean age 43.9 y, N= 426	CS	Pre-menopausal women	48- hour Dietary recalls	SES
Hinote et al. 2009 [33]	8 post-Soviet republics	>18 y, N=10,454	CS	General adults	Questions about frequency of consumption	SES
Hwang et al. 2010 [57]	Korea	Mean age: 23.7 y, N=570	CS	Vietnamese female marriage immigrants	1-day Dietary recalls	SES, PA, AM
Wardle et al. 2000 [56]	UK	Mean Age: 36.29 y, N=58	CS	Staff of a store	24-hour Dietary recalls	SES, AM

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725 **Table 2.** Characteristics extracted from the 24 included studies: BS (Breakfast skippers), BE (Breakfast eaters), CS (Cross-Sectional), LG
726 (Longitudinal), y (years), m (months), FFQ (Food Frequency Questionnaire, WFR (Weigh food record), SES (Socioeconomic status), PA (Physical
727 Activity), AM (Anthropometric measures), - (not reported).

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Author, Year	Stress Assessment Tool	Diet Quality Index	Association between Stress and Diet Quality	β coefficient, r, or OR
Richardson et al. 2015[43]	- 14-item Perceived Stress Scale	- Healthy Eating Index 2010	\Leftrightarrow	$\beta = -0.18$ (S.E 0.10, $p=0.08$)
Ferranti et al. 2013 [10]	- 14-item Perceived Stress Scale - Beck Depression Inventory II	- Alternate Healthy Eating Index - Mediterranean Diet Index - Dietary Approach o Stop Hypertension Index	\Leftrightarrow	Not reported
Isasi et al. 2015 [42]	- 10-item Perceived Stress Scale - 8-item Chronic stress burden	- Alternate Healthy Eating Index 2010	↓	$\beta = -0.61$ (-1.18 to -0.03)
El Ansari et al. 2015 [39]	- 4-item Perceived Stress Scale	- Dietary Guideline Adherence Index	\Leftrightarrow	$r = 0.00$, $p=0.98$ $\beta = 0.00$ (-0.13 to 0.13)
Valipour et al. 2017 [44]	- 12-item General Health Questionnaire	- Dietary Approach o Stop Hypertension Index	\Leftrightarrow	OR: 1.02 (0.78-1.33)
Fowles et al. 2012 [41]	- Edinburgh Postnatal Depression Scale - Prenatal Psychosocial Profile-stress subscale	- Dietary Quality Index- Pregnancy	↓	$r = -0.35$, p is not reported
Fowles et al. 2011 [40]	- Edinburgh Postnatal Depression Scale - Prenatal Psychosocial Profile-stress subscale	- Dietary Quality Index- Pregnancy	↓	$r = -0.293$, $p < 0.01$
Widaman et al. 2016 [45]	- Wheaton Chronic Stress Inventory	- Healthy Eating Index 2010	↓ in breakfast skippers \Leftrightarrow in breakfast eaters	Empty calories ($r = -0.392$, $p = 0.027$) Empty calories ($r = -0.104$, $p = 0.53$)

732 Table 3. Data values extracted from the included eight studies on Diet Quality: β (Beta coefficients), r (correlation coefficient), OR (Odd Ratio)

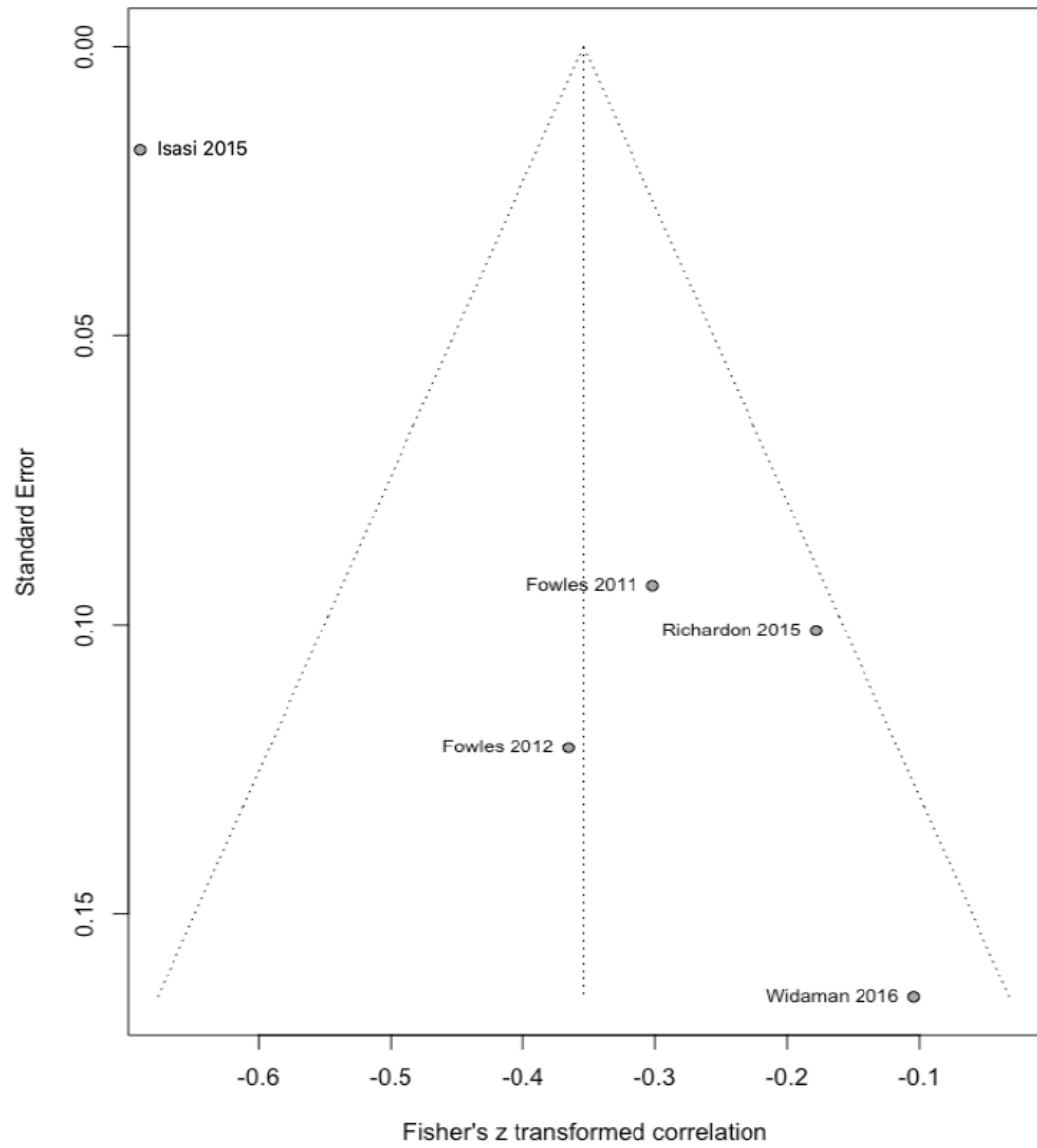
Author, Year	Stress Assessment Tool	Association between Stress and the measured Food intake and frequency of consumption	Values
Vidal et al. 2018 [1]	14-item Perceived Stress Scale	↑ Fat intake	p=0.005
Nastaskin et al. 2015 [54]	14-item Perceived Stress Scale	↑ Fat intake ↑ Sodium intake	r=. 35, p<0.01 r=. 23, p=0.07
Pettit et al. 2011 [59]	14-item Perceived Stress Scale	↑ Energy Drink intake	r=. 235, p<0.01
Mikolajczyk et al. 2009 [34]	14-item Perceived Stress Scale	↑ Sweets, cookies, snacks, fast foods ↓ Fruits/vegetables	p=0.03 p<0.01
Errisuriz et al. 2016 [58]	Perceived stress single item scale (0-10)	↑ Soda, coffee, energy drink, salty snack, sweet snack, frozen food, and fast food consumption	p<0.05
El Ansari et al. 2014 [15]	4-item Perceived Stress Scale	↑ Sweets, cookies, snacks, fast food ↓ Fruits and vegetables	P=0.017 P=0.002
Ng et al. 2003 [55]	4-item Perceived Stress Scale	↑ High Fat diet <=> Alcohol intake	p<0.01 p=0.4
Barrington et al. 2012 [37]	10-item Perceived Stress Scale	↑ Fast food intake ↓ Fruits and vegetables intake	z = 3.00, P= .003 z = -3.01, P = .003
Grossniklaus et al. 2010 [61]	Perceived Stress Scale	<=> food and beverage intake	p>0.05
Papier et al. 2015 [16]	Depression Anxiety Stress Scale (DASS)	↑ processed foods ↓ meat alternatives ↓ vegetables and fruits	p<0.01 p<0.05 p<0.01
Roohafza et al. 2013 [35]	-A12-item General Health Questionnaire (GHQ-12)	↑ Saturated oils ↓ Unsaturated oils ↓ Fruits ↓ Vegetables ↓ Meat	p<0.01 p<0.01 p<0.01 p=0.02 p=0.03

		↓ dairy products	p<0.01
Gonzalez et al. 2013 [60]	Cognitivist Systemic Model Academic Stress scale	↑ Alcohol intake	p<0.05
Tseng et al. 2011 [36]	Migration–Acculturation Stressor Scale	↑ Energy density ↑ % energy from fat ↓ total grams of grains ↓ Overall grain intake	-(β= 0.002, p=0.04) -(β=0.06, p= 0.05) -(β=-11.3, p<0.0001) -(β=-0.18, p=0.03)
Hinote et al. 2009 [33]	12-item distress scale	↓ Meat, fish, vegetables, fruits, animal fat	p<0.001
Hwang et al. 2010 [57]	Psychological Well-Being Index	- ↓ energy intake - ↓ carbohydrates - ↓ protein - ↓ fat - ↓ calcium - ↓ vitamin A - ↓ zinc - ↓ thiamine - ↓ riboflavin - ↓ folate	-p=0.011 -p=0.004 -p=0.021 -p=0.021 -p=0.042 -p=0.039 -p=0.005 -p=0.006 -p=0.013 -p=0.004
Wardle et al. 2000 [56]	10-item Perceived Stress Scale	- ↑ energy intake - ↑ saturated fats intake - ↑ fat intake	-p<0.05 -p<0.01 -p<0.05

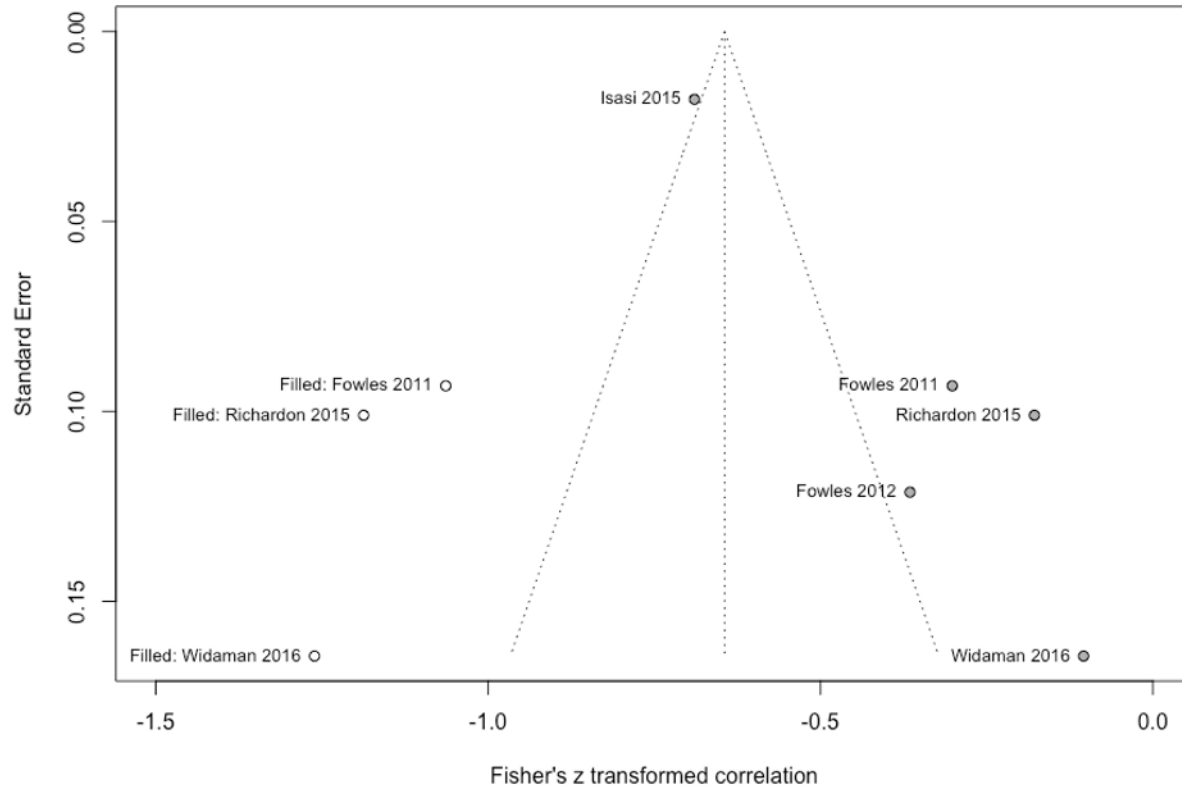
734 **Table 4.** Data values extracted from the included studies on food intake and frequency of consumption: ↑ (increase), ↓ (decrease), <=> (no association)

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738 **Appendix 7**



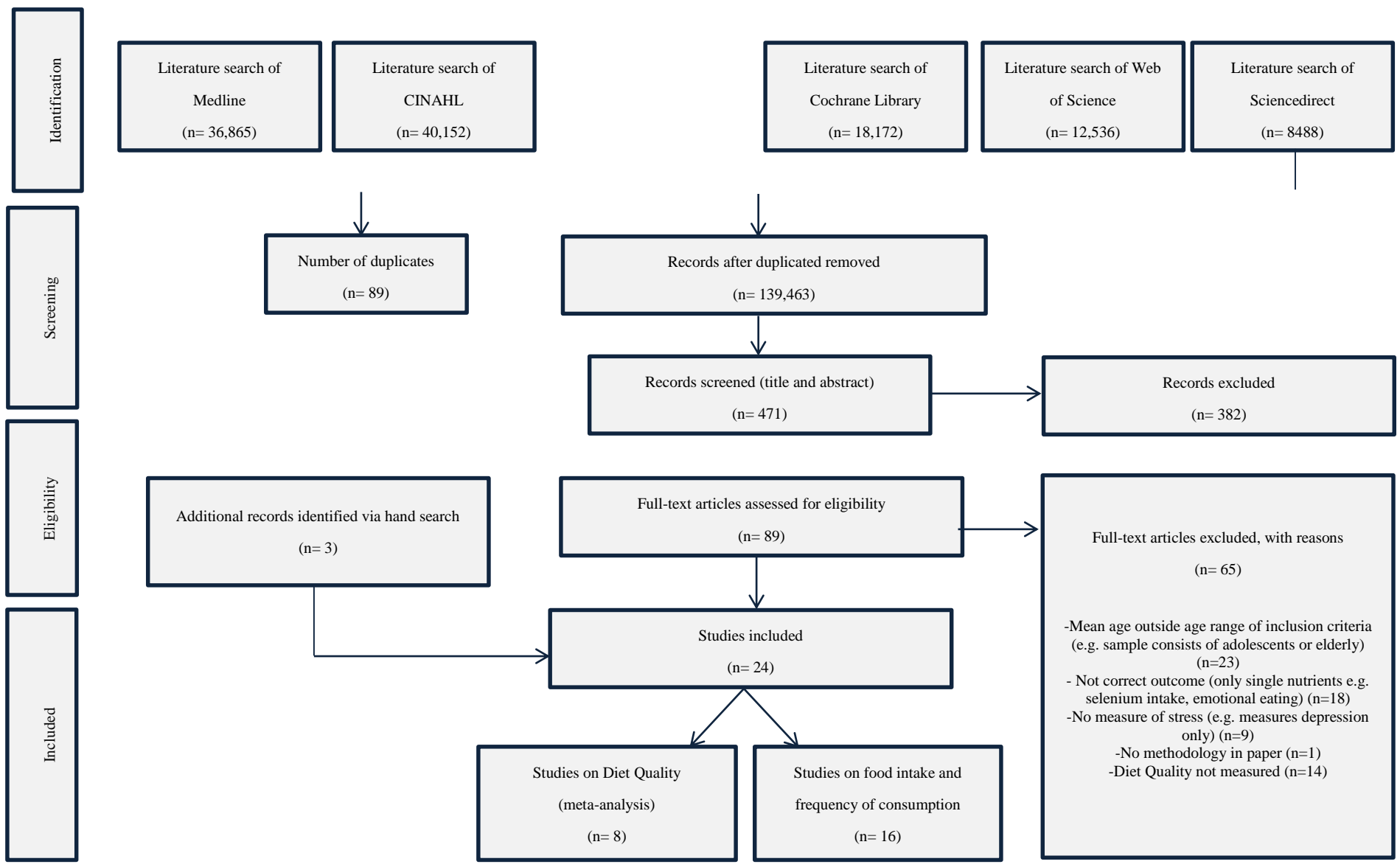
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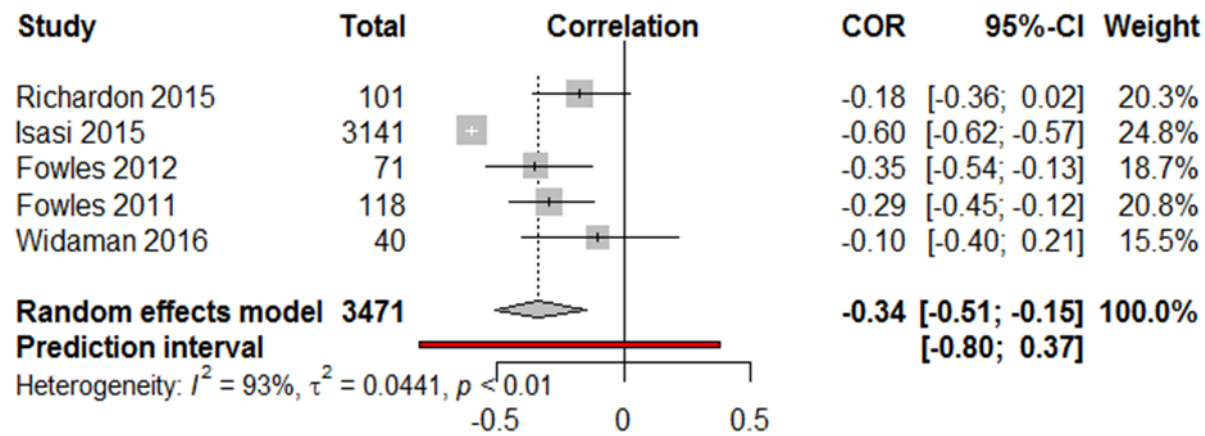
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759 **Figure 2.** Association between stress and diet quality (five studies based on correlation coefficient “r” and converted β coefficients to “r”).

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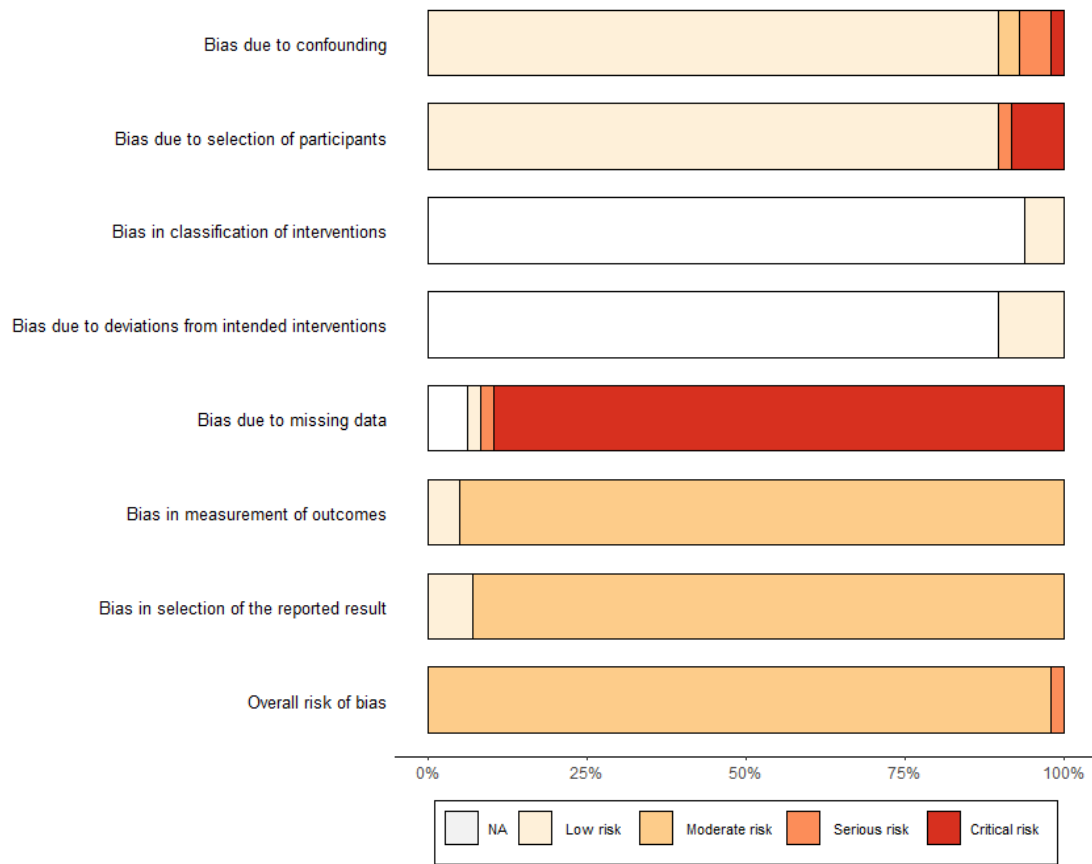


Figure 3. Weighed bar plot of the distribution of risk-of-bias judgments within each bias domain

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