*STRESS AND EATING BEHAVIOURS IN ADULTS 1*

**STRESS AND EATING BEHAVIOURS IN HEALTHY ADULTS:**

**A SYSTEMATIC REVIEW AND META-ANALYSIS**

Deborah Hill1, Mark Conner1, Faye Clancy1, Rachael Moss1, Sarah Wilding1, Matt Bristow2

& Daryl B. O’Connor1.

1. *School of Psychology, University of Leeds, Leeds, LS2 9JT.*
2. *Department of Psychology, Anglia Ruskin University, Cambridge, CB1 1PT.*

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*Corresponding author:*

Daryl B. O’Connor

School of Psychology

University of Leeds

Leeds, LS2 9JT

Email: d.b.oconnor@leeds.ac.uk

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# Abstract

Stress leads to detrimental health outcomes through direct biological and indirect behavioural changes. Stress can lead to disruption to normal eating behaviours, although the strength of these associations is unknown. This is the first meta-analysis to determine the strength of the stress-eating relationship in healthy adults and to explore the impact of potential moderators. Studies included had a clearly defined measure of stress (i.e., any noxious event or episode in one’s environment with the exclusion of emotional distress) that was linked to non-disordered eating. Key terms were searched in Medline, PsycInfo and Ovid databases (23,104 studies identified). 54 studies (combined *N* = 119,820) were retained in the meta-analysis. A small, positive effect size was found for the stress-overall food intake relationship (*Hedges’ g =*

0.114). Stress was associated with increased consumption of unhealthy foods (*Hedges’ g =* 0.116) but decreased consumption of healthy foods (*Hedges’ g =* -0.111). Only one significant moderator (restraint on stress-unhealthy eating) was identified. This meta-analysis identified the magnitude of the effect of stress on eating behaviour outcomes. Significant heterogeneity was observed that was not explained by the moderators examined. Further research on moderators of the stress-eating relationship is required and should distinguish effects for healthy versus unhealthy eating.

Key words

Stress; eating behaviour; meta-analysis; eating styles; obesity; restrained eating.

# Introduction

Understanding the influence of stress on health presents an ongoing challenge due to the complex nature of stress and the behavioural, endocrine and neural systems involved

(Finch, Tiongco-Hofschneider, & Tomiyama, 2019; O’Connor, Thayer, & Vedhara, in press). Previous research has shown that high levels of stress have been directly linked with greater risk of a range of diseases and health conditions such as cardiovascular disease, hypertension, stroke, obesity, immune function, and accelerated rates of disease progression (Cohen et al., 2012; Cohen, Janicki-Deverts, & Miller, 2007; Morera, Marchiori, Medrano, & Defagó, 2019; O’Connor et al., 2021; Steptoe & Kivimäki, 2012; Tomiyama, 2019). Stress is thought to influence health via two distinct but interacting pathways: a direct, biological pathway (e.g., by influencing neuroendocrine and autonomic processes) and an indirect, behavioural pathway (e.g., by influencing habitual and non-habitual health behaviours) (O’Connor et al., 2021). These pathways are likely to operate in a bi-directional fashion, with changes in behaviour impacting biology, and changes in biology influencing behavioural changes which affect health.

Over the past twenty-five years, a considerable amount of research has investigated the relationship between stress and eating behaviour and a large number of studies have shown that stress is associated with changes in food intake in adults and children (Araiza & Lobel, 2018; Dallman et al., 2003; Greeno & Wing, 1994; Hill, Moss, Sykes-Muskett,

Conner, & O'Connor, 2018; O’Connor & Conner, 2011; Wardle, Steptoe, Oliver, & Lipsey, 2000). In fact, it has been estimated that 35-40% of people increase their food intake when experiencing stress, whilst the remaining proportion either decrease or do not change their food intake in response to stress (Oliver & Wardle, 1999; Pool, Delplanque, Coppin, & Sander, 2015; Sproesser, Schupp, & Renner, 2014). Moreover, where changes are observed in eating habits under conditions of stress, these have been shown to manifest in two contrasting ways (Greeno & Wing, 1994; Hill et al., 2018; O’Connor & Conner, 2011; Wardle et al., 2000). For example, where stress is experienced chronically, an individual may increase their food intake in response to stress, which can in turn lead to weight gain through chronic, positive energy balance (Torres & Nowson, 2007; Newman, O’Connor, & Conner 2007). In contrast, an individual may decrease their food intake, subsequently leading to weight loss through chronic, negative energy balance. However, the dysregulation of biobehavioural responses to food consumption, in particular, increased high fat, energy dense foods under conditions of stress has received the most research attention, given the longerterm implications for physical disease risk (O’Connor & Conner, 2011; Ulrich-Lai et al., 2010). Nevertheless, surprisingly, there has been no meta-analytical synthesis of the stresseating evidence base and the magnitude of this relationship remains unknown.

The concept of stress has had a long and productive history, but it also has its critics who have highlighted the simplistic, inconsistent and imprecise use of the term (see Segerstrom & O’Connor, 2012). Stress can be conceptualised as a stimulus, a response, or as a transaction between the person and their environment (O’Connor & Ferguson, 2016). In the latter case, stress is defined as “a particular relationship between the person and the environment that is appraised by the person as taxing or exceeding his or her resources and endangering his or her well-being” (Lazarus & Folkman, 1984; p. 19). The notion of stress appraisal is central to Lazarus and Folkman’s (1984) transactional model of stress. Stress appraisals are the interpretations of events in terms of their benefit or harm for the individual and are posited to have two dimensions: primary and secondary appraisals (Lazarus & Folkman, 1984). Primary appraisal involves the evaluation of the risks, demands, or challenges of a situation, while secondary appraisal evaluates the availability of perceived resources and whether anything can be done to alter the outcome of the situation. Therefore, in this meta-analysis, informed by the transactional model, stress was considered to be any noxious event or episode which has the potential to be perceived as threatening, harmful or loss provoking to an individual (Lazarus, 1999). Moreover, given the conceptualisation issues mentioned above, in the current meta-analysis, we included only studies that incorporated: i) a measure of stress (i.e., any noxious event or episode in one’s environment that could be appraised as threatening, risky or harmful) which was clearly defined (in the description and/or study design employed) within the paper and, ii) a measure of eating behaviour linked to that stress measure. More specifically, included studies were required to have a discrete measure of stress that captured the participants’ appraisal of a recent, current or on-going stressor, or included a validated technique or paradigm developed through research that reliably induces stress (e.g., the Trier Social Stress Test).Studies which exclusively focused on emotions and/or emotional distress were excluded as these constructs were considered to be responses to stressors, opposed to a specified measure of stress itself. In addition, this exclusion was added in order to refine the scope of the review.

# Moderators of stress and eating

The present review also aimed to investigate a range of potential moderating variables of the stress and eating relationship. The rationale for including specific moderating variables was informed by previous literature reviews (see below) and by the extent to which the relevant data was available in the identified studies for inclusion (outlined in the Method).

As noted above, one key moderator may be the nature of the food consumed in response to stress, with some foods such as unhealthy high fat foods more likely to be consumed and some foods such as healthy low fat and low sugar foods less likely to be consumed. Given the potential importance of food type we structured our examination of other moderators by food type (i.e., exploring moderating effects across all foods and within healthy and unhealthy foods). Moreover, the individual differences model of stress and eating suggests that differences in learning history, attitudes towards eating, or biology produce variations in vulnerability to the effects of stress (Araiza & Lobel, 2018; Gibson, 2012; Greeno & Wing, 1994; O’Connor & Conner, 2011; Tomiyama, 2019). Those exhibiting vulnerability are assumed to respond to stress with an environmental, psychological or physiological change that has an effect on eating behaviour. Previous research has shown that stress influences the type of foods chosen as well as the amount of food consumed (Araiza & Lobel, 2018; Hill et al., 2018; O’Connor & Conner, 2011). In some individuals, the intake of unhealthy foods (i.e., high energy low nutrient foods) appears to increase as a function of stress (for a literature review see Lyzwinski, Caffery, Bambling, & Edirippulige, 2018). Studies have found that stress is associated with increased consumption of unhealthy foods, particularly those high in fat and sugar (Newman et al., 2007; Roberts, Campbell, & Troop, 2014). In contrast, stress has been negatively associated with the consumption of low energy high nutrient foods (i.e., healthy foods), particularly fruit and vegetables, where intake of these foods decreases as stress increases (Mikolajczyk, El Ansari, & Maxwell, 2009; O'Connor et al., 2008; Wallis & Hetherington, 2009).

Reward theories posit that, under conditions of stress, changes in glucocorticoids (including cortisol) and corticotropin-releasing factor sensitize areas of the brain associated with reward (e.g., nucleus accumbens), increasing the drive to eat high energy, low nutrient and highly palatable foods (Cottone et al., 2009, Sinha & Jastreboff, 2013). Consequently, eating habits are maintained through a positive feedback loop where highly palatable foods are perceived as being rewarding under conditions of stress which in turn enhances the salience of these foods (Nieuwenhuizen & Rutters, 2008; Sominsky & Spencer, 2014). Given these differential effects of stress on types of food intake, previous reviews have explored the impact of stress on unhealthy and healthy eating behaviour, together with overall food intake

(e.g., Adam & Epel, 2007; Araiza & Lobel, 2018; Hill et al., 2018; Lyzwinski et al., 2018,

Torres & Nowson, 2007).

Several groups have been identified who likely differ in their responses to stress and these include: women versus men; normal weight versus overweight/obese; restrained (i.e., those attempting to control their food intake or dieters) versus unrestrained eaters. Age is another potential moderating variable that has received less research attention but that is considered in the current meta-analysis. Alongside individual differences variables, it is likely that additional heterogeneity in the stress-eating effect size will be accounted for by study specific characteristics, such as study quality, the type of stress measure included in the study, and the sample size. Therefore, these study specific characteristics were also included as potential moderating variables. The rationale for including each of these moderating variables is presented briefly below.

The effect of stress on eating behaviour is thought to influence women and men differently. Research has indicated that females are more likely to change their normal eating behaviours when experiencing stress compared to males (Mikolajczyk et al., 2009; Sims et al., 2008; Stone & Brownell, 1994; Weinstein, Shide, & Rolls, 1997); however this difference between genders has not been consistently found in previous research (Barrington, Beresford, McGregor, & White, 2014; Conner, Fitter, & Fletcher, 1999; El Ansari & Berg-Beckhoff, 2015; Reichenberger et al., 2018). Furthermore, some studies have used exclusively female samples (e.g., Habhab, Sheldon, & Loeb, 2009; Wallis & Hetherington, 2009), making it difficult to interpret the strength of stress-related eating in males and females separately.

Body weight has been found to influence stress-related food consumption. Previous studies have found that weight is positively associated with stress-related eating behaviours, where heavier individuals are more susceptible to increased food consumption when stressed compared to those lower in weight (Cotter & Kelly, 2018; Greeno & Wing, 1994; Sinha 2018; Tomiyama, 2019; Yau & Potenza, 2013). However, the findings from some earlier reviews have been inconsistent (e.g., Greeno & Wing, 1994), therefore, it would be useful to establish in the broader, cumulative literature whether body weight (e.g., normal weight versus overweight/obese) moderates the stress-eating relationship.

Eating styles are thought to moderate food consumption when experiencing stress

(e.g., restraint, emotional, and external eating; Adam & Epel, 2007; Greeno & Wing, 1994; Wardle et al., 2000). In particular, research has found that individuals higher in dietary restraint and emotional eating are more likely to engage in stress-related eating behaviours compared to those lower in these styles (Adriaanse, de Ridder, & Evers, 2011; O'Connor, Jones, Conner, McMillan, & Ferguson, 2008; Torres & Nowson, 2007; Wallis & Hetherington, 2004). Nevertheless, the extent to which these variables are robust and consistent moderators of the stress-eating relationship is unclear.

The final individual differences variable considered as a potential moderator of the stress-eating relationship is age. The effects of stress on eating outcomes have been investigated across a range of ages, with findings from studies in children and adolescents (Hill et al., 2018; O’Connor, 2018) and adults (Araiza & Lobel, 2018; Lyzwinski et al., 2018). However, evidence is beginning to emerge to suggest that there may be differences in the triggers of food intake between children and adults. For example, Moss, Conner, and O’Connor (2020a), have recently shown that unhealthy snack responses to negative emotion are greater in young adults compared to children and that healthy snack responses to positive emotion are greater in children compared to adults. These findings notwithstanding, it is important to establish whether the effects of stress on eating behaviour are similar or different across samples of adults with different ages.

As outlined above, it is also important to establish the extent to which study specific characteristics may also account for the heterogeneity in stress-eating findings. In particular, we were interested in exploring the influence of study quality, sample size and type of stress measure. Study quality has been identified as a longstanding issue in stress research (e.g., Kasl & Cooper, 1987) and has been found to be a key moderator in related reviews and metaanalyses (e.g., Wardle, Chida, Gibson, Whitaker, & Steptoe, 2011). Moreover, study quality is a useful approximation to compare studies against differing criteria, including sampling methods, consideration of potential covariates and validity and reliability of measures used. Using three categories of study quality (weak, moderate and strong), the present metaanalysis aimed to determine whether these study factors would influence the strength of potential effects between stress and food consumption (both overall food consumption, and intake of healthy and unhealthy foods). Sample size was included as a moderator in the present meta-analysis to determine whether the strength of associations between stress and food consumption was influenced by the reported sample sizes of studies included in this review.

We were also interested in exploring whether the type of stress measure moderated the strength of the relationship between stress and eating. Previous research has found associations between stress and eating habits using different types of study design, including stress induction paradigms (e.g., Oliver, Wardle, & Gibson, 2000), daily diary studies (e.g., Conner et al., 1999, O’Connor et al., 2008) and questionnaire-based surveys of perceived stress at different time points (e.g., Vidal et al., 2018). Therefore, we wanted to determine whether the type of stress measure (either perceived or induced stress) moderated associations between stress and food consumption.

# Aims

To summarise, this review aimed to synthesize previous research on stress-eating relationships in healthy adults and to determine the strength of the association. Furthermore, the review aimed to investigate the effects of stress on the amount of overall food consumed, as well as separately for unhealthy and healthy foods along with an examination of moderating variables of the stress and food intake relationship (i.e., gender, weight status, eating styles, age, study quality, stress measure and sample size). Given the hypothesized differences between unhealthy and healthy eating, the moderator analyses were performed across the full sample and then separately within studies measuring unhealthy or healthy eating as outcomes.

**Method**

# Search Terms

The systematic review and meta-analysis was registered on PROSPERO on the 12th

December 2017 (record number CRD42017082646). Online databases were searched on the 17th of October 2019 using key terms which were combined using Boolean operators. Key terms were searched in PsycINFO (1806 to Present) and Ovid databases (Ovid MEDLINE and Epub Ahead of Print, In-Process and other Non-Indexed Citations, Daily and Versions, 1946 to October 7th 2019). The database search was limited to human studies, English

language, journal articles and restricted by age (≥ 18 years old). Search terms were based on those used in a previous meta-analysis (Hill et al., 2018) and based on key terms used in relevant studies. The search terms were informed by the conceptualisation of stress outlined for the purposes of this meta-analysis (see supplementary materials full list of search terms in an example search strategy). Additionally, reference lists of papers included at full text level were hand searched to include relevant studies which were not initially identified via the online database search.

# Inclusion and Exclusion Criteria

Papers were screened for their inclusion in the meta-analysis based on the study population, stress measurement used and type of eating behaviour. Papers were included in the review if participants were aged 18 years or older. Studies that were partially within the age range (for example 16 to 25 years old) were retained in the screening process to determine whether data were available on the adult participants within the study. Studies that reported a mean age of at least 18 years old were retained in the meta-analysis. The review included any healthy populations of adults, which was defined as individuals without any preexisting physical or psychological illnesses. Only healthy adults were included due to the comorbidities between psychological wellbeing and poorer health generally (Scott et al., 2016). Similarly, studies that focused exclusively on clinical patients or individuals with disordered eating behaviours (e.g., bulimia) were excluded from the review.

In addition, studies were retained in the review if they included a measurement of stress and a clear eating outcome that was linked to the stress measure. More specifically, included studies were required to have a discrete measure of stress that captured the participants’ appraisal of recent, current or on-going stressors (that have the potential to be perceived as threatening, harmful or loss provoking) or included a validated technique or paradigm developed through research that reliably induces stress. This could include perceptions and appraisals of stress (measured via standardised questionnaires, daily diaries and other selfreport measures of acute, on-going or chronic stress) and laboratory-based inductions to stimulate the experience of stress (e.g., Trier Social Stress Task; Kirschbaum, Pirke, & Hellhammer, 1993). Studies which measured constructs other than stress, such as emotional distress (e.g., the Patient Health Questionnaire, Spitzer et al., 1999) anxiety (e.g., State-Trait

Anxiety Inventory, Spielberger, Gorusch, & Lushene, 1970) or negative affect (e.g., Positive And Negative Affect Schedule, Crawford & Henry, 2004) were not included in the current review. Similarly, studies which did not use a validated measure of stress or did not include a manipulation check for the measurement of stress (such as Sproesser et al., 2014) were excluded. We considered emotional distress and negative affect to be responses to stressors

(and outwith the specific conceptualisation of stress outlined earlier).

Finally, as indicated above, studies were retained in the review if they included some form of food intake as an eating behaviour that was clearly linked to a stress measure. Eating behaviours included dietary habits, snack consumption, food frequency measures and/or macronutrient intake. Studies were excluded from the review if they focused on body weight as an outcome measure (such as BMI or adiposity). Similarly, studies which measured behaviours around eating without the inclusion of any food intake (such as dietary restraint) were also excluded from the review.

# Data and Variable Coding

Studies were coded based on the type of stress measure and the type of eating outcome as previously outlined in Hill et al. (2018). Stress measures were categorised into perceived stress (which included daily diary studies) or induced stress (such as a stress induction paradigm or stress vs no stress periods). Eating outcomes were categorised into three types of food intake: healthy, unhealthy and other foods. The categorisation of foods was based on nutritional quality of foods (Poon et al., 2018). For example, healthy foods were identified as those which are health promoting, such as intake of low energy, high nutrient foods like fruit and vegetables. Unhealthy foods were identified as high energy, low nutrient foods which may be health limiting. Foods that did not fall into either healthy or unhealthy categories, such as macronutrients (like protein, carbohydrates), total energy intake, number of snacks consumed, or non-specific food groups where the nutrient profile could not be accurately determined (e.g., cereals, meat products and fish/seafood products) were categorised as being other foods. Note that this eating outcome was not used in moderation analyses due to the ambiguity of foods included in this categorisation. Study specific details on the categorisation of food outcomes are included as footnotes in the supplementary materials.

Studies with more than one type of food intake were included within each eating outcome (i.e., appearing either once, twice or three times depending on the types of food consumption included within a study). However, to ensure studies were not ‘double counted’ the sample sizes were reduced appropriately. For example, where a study had reported two eating outcomes, sample sizes were halved, while a study reporting three eating outcomes the sample size was divided by three. This correction was only used to allow a meaningful subgroup analysis across the three eating types. This method of accounting for within-study dependencies was compared with an aggregation method (Hoyt & Del Re, 2015) which found minimal differences to calculated effect sizes (variations between 0.007 to 0.013 in Hedge’s

g), with the reduction in sample sizes producing more conservative estimates of effects sizes than an aggregation method. All data included in the current meta-analysis has been shared and is freely available on the Open Science Framework (see https://osf.io/jk7m9/).

# Quality Assessment

A quality assessment tool was developed based on the Effective Public Health

Practice Project (EPHPP) assessment tool for quantitative studies (Thomas, Ciliska, Dobbins, & Micucci, 2004). The EPHPP was developed for assessing the quality of randomised controlled trials (RCTs) and includes six component scoring sections; Selection Bias, Study Design, Confounders, Blinding, Data Collection Methods and Withdrawals / Drop-outs. One section (Blinding) was specific to RCTs and was removed from the EPHPP for use in this review. Studies were assessed on the remaining 5 sections (See supplementary materials for the full assessment tool and with scoring instructions). Two component scoring sections (Study Design and Data Collection Methods) were adapted to better reflect the type of studies retained in this review. In the Study Design component section, a rating of strong was given to studies which had used an objective measure of food intake, either across multiple time points or at a single time point. A moderate quality rating was given to studies which had adopted a daily diary methodology or had investigated stress at more than one time point

(including longitudinal studies). Finally, a weak Study Design rating was given to studies which had used stress and subjective eating measures at only one time point. Similarly, if the study design could not be determined, it was coded as weak in this component section.

The Data Collection Methods component section was adapted to assess the reliability and validity of stress and eating measures independently to one another. A study was rated as strong in quality when both the stress and eating measures were valid and reliable. A moderate rating was given to studies where both measures are shown to be valid, and one or both measures were either not reliable, or reliability for the measure was not reported. Similarly, if one measure was both valid and reliable, a moderate rating was given. Finally, a weak study quality rating was given in this component section where both the stress and eating measures were neither valid nor reliable, or where validity and reliability could not be determined.

After completion of component sections, studies were assigned a global quality rating following the method outlined by Thomas et al., (2004). Where no weak ratings were given on any of the component scales (i.e., all sections were either strong or moderate), studies were identified as being strong in study quality overall. A moderate global rating was given for studies which included one weak rating out of the 5 component rating sections. Finally, studies were coded as being weak in quality where they scored weak on two or more of the component scales.

# Data Synthesis

All studies retrieved from the initial database search were screened at title, abstract and full text levels by a reviewer. A minimum of 10% of studies were independently coded by a second reviewer (RM/SW) at title (*n =* 2,319), abstract (*n =* 39) and at full text levels (*n =* 9).

Cohen’s kappa (Cohen, 1960) value was found to be good overall for the screening process (κ = 0.84), with high agreement levels across title (κ = 0.72) and abstract levels (κ = 0.72), and perfect agreement at full text screening (κ = 1.00).

Study quality was assessed on all papers included in the review using the modified

EPHPP tool. At least 10% of studies included in the review (κ *=* 8) were assessed by an independent reviewer (RM/SW) and agreement levels were calculated. Agreement levels across the five component scales ranged from some disagreements (62%) to agreement accepted in most situations at 80% (Neuendorf, 2016). Disagreements were discussed and

resolved, resulting in perfect agreement (κ = 1.00) on study quality ratings for the studies.

# Method of Analysis

Prior to analysis all extracted data were checked by an independent reviewer (FC/SW).

Data was synthesised using Comprehensive Meta-Analysis version 3 (Borenstein, Hedges, Higgins, & Rothstein, 2005) and effect sizes were calculated using Hedges’ g to account for any small sample sizes included in the review (Orwin, 1983). Effect sizes up to 0.49 were considered to be small, between 0.50 and <0.80 medium effect sizes and ≥0.80 were considered large (Cohen, 1988). Publication bias was assessed across all studies using a funnel plot of observed and imputed effect sizes, with additional analyses used to determine the severity of potential publication bias in this review.

Standardised residuals were used to assess potential outliers in computed effect sizes. Any studies with a standardised residual > +/- 3 were further investigated using sensitivity analyses. Two studies (Boggiano et al., 2015; Conner et al., 1999) were identified as potential outliers, with standardized residual values of 6.36 and 3.07 respectively. To determine the impact of potential outliers in the analysis, each study was systematically removed from the overall analysis to determine its individual contribution. Removal of each study in turn resulted in a change to the overall effect size by -0.019 and -0.013 for each of the two studies respectively. Due to the minimal impact overall to the findings, these studies were retained in analyses.

A random effects meta-analysis was used to investigate assumed heterogeneity across studies (Riley, Higgins, & Deeks, 2011). Analyses aimed to investigate the association between stress and food consumption overall, across all studies, and determine the effect of moderating variables on this relationship. This same method was employed to investigate the effect of stress on the type of eating outcome (i.e., unhealthy and healthy foods) as well as the other moderation analyses.

The relationship between stress and overall food intake was assessed, with moderation analyses used to determine the effect of stress on type of eating behaviour (unhealthy and healthy) independently. Heterogeneity was assessed for main analyses and moderating variables using Cochran Q tests and I2 (Higgins, Thompson, Deeks, & Altman, 2003; Lipsey & Wilson, 2001), where I2 (reported as a percentage) indicates the degree of heterogeneity across studies, opposed to variance occurring due to chance (Higgins & Thompson, 2002).

Pearson’s correlations were used to determine the interdependence between the moderating variables used in analyses. Gender (where data was available for females and males separately), mean BMI, proportion healthy/overweight individuals, mean dietary restraint, mean age, study quality, stress measurement and sample size were each included as moderating variables. Where reported, mean values for dietary restraint were standardized into z-scores to control for the use of different questionnaires.

The moderating effect of categorical variables (i.e., gender, study quality and stress measure) were examined using subgroup analyses where at least four studies were present in each subgrouping. The moderating effect of continuous variables (i.e., mean BMI, proportion of healthy and overweight individuals, eating styles, mean age and sample size) was investigated using meta-regressions (maximum likelihood).

# Results

A total of 23,104 unique articles were retrieved from searching electronic databases and hand searching of reference lists (see Figure 1 for a PRISMA flow diagram; Moher, Liberati, Tetzlaff, & Altman, 2009). The main reason for exclusion from the review at title level was due to articles having no measure of stress or eating behaviours (*k* = 22,490). Of the 396 studies screened at abstract level, 146 were retained for full text screening. The main reason for exclusion at abstract level was studies not including a measure of food consumption (*k* = 120). From full text screening, 84 studies were identified for inclusion in the review. During quantitative synthesis, two studies were excluded due to using the same data set as another included paper (O'Connor, Conner, Jones, McMillan, & Ferguson, 2009; van Strien, Herman, Anschutz, Engels, & de Weerth, 2012). A further 28 studies were excluded from the review due to insufficient data, leaving 54 studies included in this review.

# Study Characteristics

The combined sample size from the 54 included studies was 119,820 (range 9 to

65,235 in individual studies), of which 64,775 were female (54.06%) and 54,742 were male (45.69%). Of the 54 studies, 23 used exclusively female participants (comprising of 3,301 participants) and two studies used exclusively male participants (total of 56 participants). Gender was not reported for 303 participants (<1%). Mean age for the total sample was 27.49 years (range 18 to >80 years were reported). Mean age was not reported in five studies. The mean BMI was 24.82 kg/m2 with a range of 20.2 kg/m2 to 36.5 kg/m2. Where reported, studies were categorised by weight status; 13 studies reported the proportion of participants who were a healthy weight (defined as a BMI from 18.5 to 24.9 kg/m2) and the proportion of participants who were overweight/obese (with a BMI over 25 kg/m2). BMI was not reported in 24 studies.

Studies were categorised based on the type of stress measurement and type of eating outcome (for details on coding, see method section). Studies which included multiple stress measures and/or eating outcomes were included within each relevant category. Most studies used a measure of perceived stress (*k =* 32). Twenty-two studies used a stress induction methodology. Similarly, studies were categorised based on the type of eating outcome. Of the 54 studies included in the review, 35 included a measure of unhealthy food consumption, 17 used healthy food consumption and 31 used a measure of other food intake.

Finally, studies were categorised based on overall study quality. The majority of the studies included in the review were identified as being weak in study quality (*k =* 30), with fewer being categorised as moderate in study quality (*k =* 19) and only 5 identified as being strong in study quality. A breakdown of study quality across the five component ratings is presented in Figure 2. Over half of the studies included in the review were identified as at risk of selection bias where the sample may not provide an accurate reflection of the wider population (for example undergraduate university students enrolled on a Psychology course). However, 31 studies were identified as being strong in their data collection methods (for example, where studies had used valid and reliable scales to measure stress).

# Moderating variables

The selection of moderating variables was determined through the availability of data reported in studies included in the review and informed by previous research reviews (as outlined earlier). Of the moderators initially noted in the pre-registration of the review, only study design (longitudinal vs cross-sectional) was not included due to too few studies adopting a longitudinal design (*N*=1). Eating styles were considered as additional moderating variables after the completion of the pre-registration based on the potential availability of data on these variables. Whilst there were sufficient studies to conduct analyses on dietary restraint (i.e., 12 studies reported mean restraint scores), other eating styles (e.g., external and emotional eating) were not analysed due to a lack of available data.

# Main Findings

The relationship between stress and overall food intake was initially investigated. A significant positive association was found between stress and food intake, *Hedges’ g* = 0.114, *95% CIs* [0.061, 0.166], *Z* = 4.255, *p* < .001. A proportional forest plot of stress and food consumption overall is presented in Figure 3. There was considerable heterogeneity across subgroup analyses (see Table 1) and considerable heterogeneity across the 54 studies overall, *Q(53)* =822.528, *p* < .001, *I2* = 93.556. Therefore, further analyses were conducted to investigate whether type of food intake contributed to the high level of heterogeneity

(Higgins & Green, 2011).

# Publication Bias

The presence of publication bias was investigated across the 54 studies included in the review. Egger’s regression analyses (Egger, Smith, Schneider, & Minder, 1997) indicated that there was not significant publication bias within the review (intercept = 1.086, *df =* 52, *p =* .069). A funnel plot of observed and imputed standard error values (see Figure 4) indicated that there may be one missing study to the right of the mean. Duval and Tweedie’s Trim and Fill analysis (Duval & Tweedie, 2000) indicated that inclusion of the missing study would result in a small increase to the overall effect size (observed *Hedges’ g* = 0.114, *95% CIs*

[0.061, 0.166]; computed *Hedges’ g* = 0.117, *95% CIs* [0.065, 0.169]).

Sensitivity analysis was conducted to investigate the relative influence of each study on the main findings. Through the systematic removal of each study in turn, the analysis indicated that changes to the overall study findings of stress and food consumption were minimal, with the largest effect size change of -0.019 to +0.014 in the calculated Hedges’ g

(with a change of effect size range from 0.095 to 0.128).

# Independence of moderating variables

Pearson’s correlations were used to assess the independence between categorical moderating variables (study quality, stress measure and eating behaviour). No significant associations were found between these categorical moderating variables, therefore each of the moderating variables were investigated independently.

# Moderating variables on stress and eating behaviours overall

The moderating effects of gender, study quality and stress measurement were examined via subgroup analyses. For gender, studies were included where the effect of stress on eating behaviour had been reported for males and females separately. The moderating effect of proportion of females, mean age, mean BMI, proportion of healthy / overweight individuals, restraint and sample size on stress and eating overall was investigated using meta-regressions (see Table 1 and Table 3 for a summary of results).

Thirty studies included data on females only, with 9 studies including data on males only. No moderating effect of gender on the stress-eating overall relationship was found, *Q(1)* = 1.107, *p* = .293. Similarly, no moderating effect was found for the proportion of females on the stress-eating overall relationship, *coefficient =* 0.001, *standard error =* 0.002, *Z =* 0.79, *p =* .430.

Thirty studies were included in moderation analyses to investigate the effect of mean

BMI on stress and eating overall. Mean BMI was not found to moderate the relationship between stress and eating behaviours, *coefficient =* -0.003, *standard error =* 0.019, *Z = -*0.16, *p =* .872. Further analyses investigated the proportion of healthy and overweight individuals on stress and eating overall. No moderating effect was found for the proportion of healthy weight individuals, *coefficient <* .001, *standard error =* 0.003, *Z =* 0.21, *p =* .838, nor for the proportion of overweight individuals on the association between stress and eating overall, *coefficient =* 0.002, *standard error =* 0.003, *Z =* 0.76, *p =* .448.

Twelve studies were included in moderation analyses to investigate the effect of restraint on stress and eating overall. Standardised mean restraint scores were not found to moderate stress and eating overall, *coefficient =* 0.035, *standard error =* 0.088, *Z =* 0.40, *p =* .687.

Forty-nine studies were included in moderation analyses to investigate the effect of mean age on stress and eating overall. The meta-regression indicated that mean age did not moderate the association between stress and food consumption, *coefficient =* -0.003, *standard error =* 0.005, *Z =* -0.63, *p =* .531.

The moderating effect of study quality was assessed across all studies included in the review. Analyses indicated that study quality (strong, moderate, weak) did not moderate the association between stress and food intake overall, *Q(2)* = 5.990, *p* = .050; however as the Q value was trending towards significant, subgroup analyses were conducted on study quality pairings. Effect sizes were largest and significant in the moderate quality studies (*Hedges’ g* = 0.147, *95% CIs* [0.037, 0.257], *Z =* 2.629, *p =* .009), smaller in the weak study quality studies (*Hedges’ g* = 0.115, *95% CIs* [0.038, 0.193], *Z =* 2.193, *p =* .004) and smallest in the high quality studies (*Hedges’ g* = 0.039, *95% CIs* [0.007, 0.071], *Z =* 2.371, *p =* .018). However, there were no significant differences in effect sizes based on study quality categories (strong versus weak, *Q(1)* = 3.183, *p* = .074; strong versus moderate, *Q(1)* = 3.449, *p*

= .063; moderate versus weak, *Q(1)* = 0.217, *p* = .642).

The moderating effect of type of stress measurement was investigated using subgroup analyses. Overall, the type of stress measurement used (i.e., perceived vs induced) did not moderate the association between stress and eating behaviours, *Q(1)* = 0.621, *p* = .431.

Finally, the moderating effect of total sample size was assessed for all studies included in the review. The meta-regression indicated that total sample size did not moderate the association between stress and food intake overall, *coefficient* < -0.001, *standard error* <

.001, *Z =* -0.42, *p =* .673.

# Stress and type of food intake

The relationship between stress and food consumption was further investigated using unhealthy and healthy eating categories. Overall, there was a significant difference in effect sizes based on type of food intake, *Q(2)* = 41.239, *p* <.001. Analyses indicated a significant difference between unhealthy and healthy eating, *Q(1)* = 24.370, *p* < .001, where the effect sizes were significant and positive for the stress-unhealthy food consumption relationship, but significant and negative for the stress-healthy food intake relationship (Table 1). Analyses also indicated a significant difference between healthy and other food consumption, *Q(1)* = 34.757, *p <* .001, where the effect size was significant and positive for the stress-other food consumption relationship but significant and negative for the stress-healthy food intake relationship. No differences were found between unhealthy and other food intake, *Q(1)* = 1.165, *p* = .280 (Table 1). Next we explored the effects of stress in unhealthy eating and then in healthy eating. However, as noted earlier, the other food intake outcome was not used in moderation analyses due to the ambiguity of foods included in this categorisation.

# Stress and unhealthy eating outcomes

Analyses indicated a significant, positive association between stress and consumption of unhealthy foods, *Hedges’ g* = 0.116, *95% CIs* [0.055, 0.177], *Z* = 3.708, *p* < .001 (see Figure 5 for proportional forest plot of stress and unhealthy food consumption). There was significant heterogeneity between studies with measures of unhealthy food intake, *Q(35)* = 415.910, *p* < .001, *I2* = 91.825.

Next, analyses were conducted to determine the potential effect of moderators (see Table 2 for a summary of heterogeneity for categorical subgroups) on the stress-unhealthy eating relationship. Analyses indicated no moderating effects of gender, *Q(1)* = 0.683, *p* = .408, or the proportion of females, *coefficient =* 0.003, *standard error =* 0.003, *Z =* 1.27, *p =* .202 on the relationship between stress and unhealthy eating.

Furthermore, no moderating effects were found for BMI, *coefficient =* -0.011, *standard error =* 0.028, *Z = -*0.39, *p =* .709, proportion of healthy weight, *coefficient =* 0.001, *standard error =* 0.001, *Z = -*1.16, *p =* .248, or proportion of overweight, *coefficient <* -0.001, *standard error =* 0.001, *Z = -*0.25, *p =* .806, on the stress-unhealthy eating

relationship.

Six studies were included in moderation analyses to investigate the effect of restraint on the stress-unhealthy eating relationship. Mean restraint was found to significantly moderate stress and unhealthy eating, *coefficient =* -0.181, *standard error =* 0.080, *Z =* -2.28, *p =* .023. More restraint was associated with a weakening of the stress-unhealthy eating

relationship.

Mean age did not moderate the association between stress and unhealthy food consumption, *coefficient =* 0.003, *standard error =* 0.007, *Z =* 0.41, *p =* .682.

Only three studies used a measure of unhealthy eating and was strong in study quality. Therefore, subgroup analyses were conducted to investigate differences in moderate and weak study quality only. Analyses indicated no moderating effect of study quality , *Q(2)* =

3.388, *p* = .184, or type of stress measure, *Q(1)* = 0.232, *p* = .630 on the stress-unhealthy eating relationship.

Similarly, sample size did not moderate the association between stress and unhealthy eating, *coefficient* < -0.001, *standard error* < .001, *Z =* -0.35, *p =* .726.

# Stress and healthy eating outcomes

A significant, negative association was found between stress and healthy food consumption, *Hedges’ g* = -0.111, *95% CIs* [-0.165, -0.056], *Z* = -3.981, *p* < .001 (see Figure 6 for a proportional forest plot). Further analyses indicated that there was significant heterogeneity between studies with measures of healthy food intake, *Q(16)* = 136.199, *p* < .001, *I2* = 88.252.

Moderating analyses were conducted to further investigate the effect of stress on healthy food consumption (see Table 2 for a summary of heterogeneity across categorical subgroups). Similar to the effects for unhealthy eating outcomes, neither gender, *Q(1)* = 2.318, *p* = .128, nor proportion of females, *coefficient =* -0.002, *standard error =* 0.002, *Z =* -0.87, *p =* .387 was found to moderate the stress-healthy eating relationship.

Furthermore, no moderating effects were found for BMI, *coefficient =* -0.009, *standard error =* 0.010, *Z = -*0.88, *p =* .378, proportion of healthy weight, *coefficient =* -0.004, *standard error =* 0.002, *Z = -*1.96, *p =* .050, or proportion of overweight, *coefficient*

= 0.009, *standard error =* 0.005, *Z = 1.61*, *p =* .107, on the stress-healthy eating relationship.

Moderation analysis for the effect of mean restraint on stress and healthy food was not conducted as only one study had reported mean restraint and measured an intake of healthy food.

Mean age did not moderate the association between stress and healthy food consumption, *coefficient =* 0.001, *standard error =* 0.003, *Z =* 0.33, *p =* .740.

Only one study used a measure of healthy eating and was strong in study quality. Therefore, subgroup analyses were conducted to investigate differences in moderate and weak study quality only. No differences between studies rated as moderate and weak in study quality, *Q(1)* = 0.035, *p* = .851 was found in relation to the stress-healthy eating relationship.

Moderation analysis for the type of stress measurement was not conducted as only two studies had used a stress induction methodology along with an intake of healthy food. Similarly, sample size did not moderate the association between stress and healthy eating, *coefficient* < 0.001, *standard error* < .001, *Z =* 1.51, *p =* .130.

# Discussion

The findings of this meta-analysis revealed for the first time that across the existing body of research that met our criteria the strength of the relationship between stress and overall food consumption was small in magnitude. These results are in line with previous narrative literature reviews which have indicated that food consumption changes as a function of stress in different individuals (Araiza & Lobel, 2018; Greeno & Wing, 1994; Lyzwinski et al., 2018). Moreover, the small overall effect size is also consistent with estimations that 3540% of people increase their food intake when experiencing stress while others decrease or do not change their food intake (O’Connor & Conner, 2011; Oliver & Wardle, 1999; Pool et al., 2015; Sproesser et al., 2014). In addition, although the effect sizes are small, they are still noteworthy as they show that stress impacts on healthy and unhealthy food consumption differently. A large number of previous studies have focused on only one aspect of eating behaviour (e.g., between-meal snacking) or have been restricted to laboratory investigations of food intake in artificial environments (e.g., chocolate consumption in ad-libitum laboratory experiments). Therefore, the current findings emphasise the need to consider different aspects of eating behaviour and may indicate that disparate findings observed in past research may be, in part, accounted for by the variations in the type of eating behaviour and the environment in which it occurs (e.g., between-meal snacking, ad-libitum food intake). Nevertheless, the small effect sizes also suggest that stress-induced eating may not be such a major health concern in psychologically healthy non-disordered eaters as once thought. That said, as outlined below, drawing such a conclusion may be premature given the paucity of research that has carefully examined putative moderators of the stress-eating relationship (e.g., eating style, dispositional stress-related eating).

A secondary aim of this meta-analysis was to investigate the influence of two groups of moderating variables: individual differences (i.e., gender, weight, dietary restraint and age) and study specific characteristics (i.e., study quality, type of stress measure and sample size). Surprisingly, dietary restraint was found to be the only significant moderator, such that greater levels of restraint were associated with a weakening of the stress-unhealthy eating relationship. This is contrary to reported effects of restraint on the stress-eating relationship, where stress generally increases eating in people who are higher in dietary restraint compared to unrestrained eaters (Adriaanse et al., 2011; O'Connor et al., 2008; Torres & Nowson, 2007; Wallis & Hetherington, 2004). Whilst this finding is interesting, only 6 studies were included in the meta-regression for mean restraint (for the sample) on stress and unhealthy food consumption. This moderating effect may also be confounded by the quality of the data used in the present meta-analysis. Mean restraint scores were used for whole samples and standardised to account for differences in measurement methods for dietary restraint. As such, conclusions drawn from our analyses are difficult to compare to previous literature without the use of raw (individual level) data. Therefore, undue emphasis should not be placed on the findings of this moderating variable in this meta-analysis and, as such, should be interpreted with caution.

Taken together, the limited number of significant moderators identified here was unexpected given the findings of other narrative reviews and key studies in this area (e.g., Araiza & Lobel, 2018; Greeno & Wing, 1994; Lyzwinski et al., 2018; O’Connor & Conner, 2011). We recognise that some of the null effects may be explained by having relatively small numbers of studies in some of the subgroup analyses (e.g., for males *k* = 9). However, this was the exception not the rule. An alternative explanation is that the considerable unexplained heterogeneity in the stress-eating relationship is accounted for by important variables that we were unable to include in the review due to lack of studies and/or the details were not included in studies (e.g., emotional eating style, dispositional stress-related eating, cortisol reactivity, type of stressor).

It is clear that the effects of stress on eating behaviour are hugely complex. As indicated above, there is evidence emerging highlighting the role of dispositional factors or individual differences in stress-related eating that were not accounted for in the current review and which likely obscured the true magnitude of the stress-eating relationship (e.g., emotional eating scores, self-reported stress eater status). However, we found only a small number of studies that included sufficient data and as a result, we were unable to conduct any meaningful analyses on dispositional factors or individual differences in stress-related eating despite these being important factors in the stress-eating relationship. For example, Torres and Nowson (2007) make the important distinction between under- and over-eating in response to stress and highlight the differing effects of stress-eating depending on factors such as the severity of the stressor. As such, the potential insights into stress-eating are limited in the present review due to the aggregation across these different types of stresseating responders. In addition, it remains unknown the extent to which stress can induce increases in unhealthy *and* healthy eating within the same individual (i.e., is there a global increase in stress-related eating?) or whether stress triggers a switching from healthy to unhealthy eating within individuals or whether any dispositional or learned effects are limited to specific foods (e.g., unhealthy foods, snacks etc.). Consequently, we feel future research should explore the effects of dispositional factors in the stress-eating relationship and establish the approximate percentage of individuals who exhibit an increase, a decrease or no change in eating response to stress. In addition, individual differences in cortisol reactivity to stress have also been found to influence eating behaviours in adults and children and should be investigated further (Epel, Lapidus, McEwen & Brownell, 2001; Moss, Conner &

O’Connor, 2020b; Newman et al., 2007).

The considerable heterogeneity found across analyses may also be explained through individual differences in the evaluation and type of stressor experienced, which has previously been found to influence stress-related eating behaviours (Miller, Chen, & Zhou, 2007). For example, research has found that the severity of a stressor is more predictive of eating behaviours than merely whether one is experienced (Adam & Epel, 2007), although this is not consistently reported in previous research (Conner et al., 1999). Similarly, differences in food consumption exist between acute and chronic stress, where acutely experienced stress has been associated with inhibited appetite (Sominsky & Spencer, 2014) while chronically occurring stress has been linked with both increased (Tryon, Carter,

DeCant, & Laugero, 2013) and decreased food consumption, as well as weight changes (Dallman et al., 2003; Klatzkin, Baldassaro, & Hayden 2018). The type of stressor can also have a differential influence on stress-related eating behaviours. Ego-threatening stressors (O'Connor et al., 2008) and those with social evaluation (such as stress-induction paradigms) elicit much stronger stress responses and may be more likely to result in changes to normal eating behaviours (Dickerson & Kemeny, 2004). In contrast, O’Connor et al. (2008) found that stressors that were physical in nature (e.g., anxious/frightened, feeling ill, threat of attack by a dog) were associated with a reduction in between-meal snacking. Moreover, it is worth noting that few studies in this meta-analysis considered situational factors around the experience of stress (e.g., type of stressor, perceived intensity), which may have provided greater insights into stress-related eating than merely the occurrence of stress.

# Limitations

While the meta-analysis provides insights into the stress-eating relationship, there are limitations with the methodology which ought to be acknowledged. The conceptualisation of stress in the present review aimed to improve the specificity of the findings and ultimately the synthesis of data from studies where stress was clearly linked with an eating behaviour. To achieve this, a distinction was made between stress (defined as any noxious event or episode in one’s environment that could be appraised as threatening, risky or harmful) and psychological states (such as emotional distress and negative affect) which were considered to be responses to a stressor. This approach helped refine the scope of the review; however, we recognise that such refinement may have limited the generalisability of the current findings to inform the broader literature that has investigated the effects of emotions and emotional distress on eating. Moreover, it is important that researchers do not underestimate the influence of positive, as well as negative emotions, on eating behaviour (e.g., Evers, Dingemans, Junghans, & Boevé, 2018, Moss, Conner & O’Connor, 2020a).

Consequently, this differentiation between stress and other psychological states may limit the potential scope of the current review, specifically the omission of studies which consider emotional distress/anxiety/negative affect to be synonymous with stress. The definition of stress varies greatly within the literature and remains a subject of contention (O’Connor et al., 2021; Kagan, 2016). Future research should take care to clearly define stress in an effort to disentangle conceptualisations of stress, responses to stress and explore the extent to which food consumption is triggered by positive and negative emotional arousal. In addition, whilst attempts were made to include a wide variety of moderating variables of the stress and eating relationship, the range of moderators included in the present review was limited. This was mostly dictated by the availability of data reported in the studies, nevertheless, we are aware that as a result, the review does not report or test an exhaustive list of potential moderators of eating behaviours under conditions of stress.

Similar to a recent meta-analysis on emotions and eating (Evers et al., 2018), the present meta-analysis aimed to determine the impact of stress on overall food consumption. To understand this relationship further, food types were categorised into unhealthy, healthy, and other foods based on energy density and nutrient profiles. Although this method has provided useful insights into the differential effect between the types of foods consumed under stress, it does not consider the influence of food palatability on the stress-eating relationship. Under conditions of stress, highly palatable foods may be perceived as more rewarding which in turn increases the salience of these foods (Nieuwenhuizen & Rutters, 2008; Sominsky & Spencer, 2014). As such, consumption of palatable foods (regardless of their nutritional content) may attenuate the physiological effects of acute stress (Morris, Beilharz, Maniam, Reichelt, & Westbrook, 2015).

Based on the findings from this meta-analysis, there are several recommendations which should be considered in future stress and eating research generally, and specifically to address the unexplained heterogeneity identified in this review. First, studies should include more detailed measures of the nature of the stressors under consideration (e.g., acute, chronic, physical, ego-threatening etc.) and more accurate assessments of food consumption (calorie count, energy density, palatability). Inclusion of more detailed measures of food consumption, such as total energy intake will facilitate greater insights into outcomes of the stress-eating relationship such as body weight. Second, more studies are required that test key moderating variables on stress and eating habits. Although efforts were made in the current review to investigate potential moderators, instances of these being included in studies and the data reported were limited, making it difficult to obtain meaningful data on some of the potential moderators of interest. Third, researchers should routinely include measures of eating styles such as emotional eating, dietary restraint, disinhibition and external eating. Fourth, all studies should endeavour to capture accurate assessments of weight and height and diet status. Finally, studies should improve reporting practices and make study data freely available so that findings can be synthesised more accurately in meta-analyses such as this one (cf., Norris & O’Connor, 2019).

# Conclusion

Stress is associated with decreased intake of healthy foods, and increased intake of unhealthy foods; however, the magnitude of these effects is small. With the exception of dietary restraint, effect sizes were not influenced by the moderating variables included in the current meta-analysis, although the limited range of such moderators examined is worth noting. This review has highlighted the need for future research to consider factors which may account for the large proportion of unexplained heterogeneity observed in this meta-

analysis.

*Author Contributions*

DH, DOC, MC and MB identified the gap in the literature and developed a search strategy for this review. DH carried out literature searching, collation of identified papers and screening. RM/SW independently screened articles and double coded study quality for interrater agreement. DH extracted data and FC double coded all data prior to analyses. DH conducted analyses with advice from DOC and MC. DH, DOC, MC and MB wrote this manuscript. All authors checked the final version of this review and are happy to be accountable for this piece.

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Table 1. Summary of heterogeneity within and between variable analyses in the metaanalysis (*k* =54).

Number of

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Subgroup | Variables | study outcomes  (*k*) & sample size | Effect size [95%  CIs] Mixed  Effects Model | I2% | Q and p  value  (Within studies) | Q & p  value  (Between  studies) |

(*n*)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Eating behaviour category | Unhealthy  Healthy | *k=35 n*=56,858  *k=17 n*=43,989 | 0.149  [0.068, 0.231]  -0.131  [-0.207, -0.055] | 91.136%  86.186% | 383.558  (<.001)  115.826  (<.001) | 41.239  (<.001)\*\* |
|  | Other | *k=33 n*=19,072 | 0.215  [0.129, 0.301] | 89.641% | 308.920  (<.001) |  |

Overall: *Hedges’ g* = 0.063, *95% CIs* [0.016, 0.110], *Z* = 2.646, *p* = .008

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Stress  Measure | Perceived[[1]](#footnote-1) | *k=32 n*=118,607 | 0.100  [0.041, 0.160] | 95.953% | 766.094  (<.001) | 0.621 (.431) |
|  | Induced | *k=22 n*=1,213 | 0.156  [0.030, 0.283] | 51.721% | 43.498  (.003) |  |

Overall: *Hedges’ g* = 0.110, *95% CIs* [0.057, 0.164], *Z* = 4.026, *p* < .001

Study Strong *k=5* 0.039 <1% 2.776 5.990

quality *n*=2,277 [0.007, 0.071] (.596) (.050)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Moderate | *k=*19 0.147  *n*=100,201 [0.037, 0.257] | 97.102% 621.166  (<.001) |
|  | Weak | *k=*30 0.115  *n*=17,342 [0.038, 0.193] | 85.081% 194.386  (<.001) |
|  |  | Overall: *Hedges’ g* = 0.057, *95% CIs* | [0.028, 0.085], *Z* = 3.877, *p* < .001 |
| Gender | Female | *k=*30 0.149  *n*=15,336 [0.041, 0.257] | 88.088% 243.447 1.107 (<.001) (.293) |
|  | Male | *k=*9 -0.014  *n*=8,337 [-0.297, 0.270] | 95.923% 196.205  (<.001) |

Overall: *Hedges’ g* = 0.057, *95% CIs* [0.028, 0.085], *Z* = 3.877, *p* < .001

*Note*: \*\* Significant at p < .001

Table 2. Summary of heterogeneity within and between studies on stress and unhealthy (*k =*35) and healthy eating behaviours (*k* =17).

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Subgroup | Variables  (Number of outcomes) | **Unhealthy eating outcomes (***k* ***=*35)** | | | |  |  | **Healthy eating outcomes (***k* **=17)** | |  |
| Number of  study outcomes  (*k*) & sample size (*n*) | Effect size [95%  CIs] Mixed  Effects Model | I2% | Q and p  value  (Within studies) | Q & p  value  (Between  studies) | Number of  study outcomes  (*k*) & sample size  (*n*) | Effect size [95%  I2%  CIs] Mixed  Effects Model | Q and p  value (Within studies) | Q & p  value  (Between  studies) |
| Stress  Measure | Perceived | *k=24 n*=97,437 | 0.125  [0.060, 0.190] | 94.153% | 393.386  (<.001) | 0.232 (.630) |  | Too few studies for subgroup anal | ysis |  |
|  | Induced | *k=11 n*=559 | 0.065  [-0.170, 0.301] | 55.599% | 22.522  (<.001) |  |  |  | |  |
| Study quality | Moderate | Too few studies for subgroup analysis  *k=11* 0.206 96.446%  *n*=79,257 [0.041, 0.371] | | | 281.338  (<.001) | 1.155 (.283) | *k=6 n*=72,249 | Too few studies for subgroup  -0.144 94.296%  [-0.240, 0.012] | analysis  87.661  (<.001) | 0.035 (.851) |
|  | Weak | *k=21* 0.101 83.632%  *n*=16,580 [0.005, 0.197] | | | 122.191  (<.001) |  | *k=10 n*=11,926 | -0.127 43.351%  [-0.188, -0.066] | 15.887  (.005) |  |
| Gender | Female | *k=19* 0.145 91.997%  *n*=14,815 [0.009, 0.281] | | | 224.925  (<.001) | 0.683 (.408) | *k=6 n*=5,832 | -0.116 61.790%  [-0.203, -0.030] | 13.085  (.023) | 2.318 (.128) |

*STRESS AND EATING BEHAVIOUR IN ADULTS 52*

Male

*k=6*

*n*

=8,263

0.013

[-0.267, 0.294]

151.173

%

96.693

(<.001)

*k=5*

*n*

=2,773

-0.258

[-0.418, -0.097]

78.448

18.560

%

(.001)

Table 3. Summary of findings from meta-regressions on stress and type of food intake.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Overall** | |  |  | **Unhealthy eating outcomes** | | | |  | **Healthy eating outcomes** | | | |  |
| Coefficient | 95%  CIs | Standard  Error | Zscore | pvalue | Coefficient | 95%  CIs | Standard  Error | Zscore | pvalue | 95%  Coefficient  CIs | | Standard  Error | Zscore | pvalue |
| Proportion female | 0.001 | -0.002,  0.005 | 0.002 | 0.79 | .430 | 0.003 | -0.002,  0.008 | 0.003 | 1.27 | .202 | -0.002 | -0.005,  0.002 | 0.002 | -0.87 | .387 |
| Mean BMI | -0.003 | -0.040,  0.034 | 0.019 | -0.16 | .872 | -0.011 | -0.065,  0.044 | 0.028 | -0.39 | .709 | -0.009 | -0.028,  0.011 | 0.010 | -0.88 | .378 |
| Proportion healthy weight | <.001 | -0.005,  0.007 | 0.003 | 0.21 | .838 | 0.001 | -0.003,  0.001 | 0.001 | -1.16 | .248 | -0.004 | -0.008,  <-.001 | 0.002 | -1.96 | .050 |
| Proportion overweight | 0.002 | -0.003,  0.007 | 0.003 | 0.76 | .448 | <-.001 | -0.003,  0.002 | 0.001 | -0.25 | .806 | 0.009 | -0.002,  0.019 | 0.005 | 1.61 | .107 |
| Dietary restraint | 0.035 | -0.136,  0.207 | 0.088 | 0.40 | .687 | -0.181 | -0.337,  -0.026 | 0.080 | -2.28 | .023 |  | *Too few studies for analysis* | | |  |
| Mean age | -0.003 | -0.012,  0.006 | 0.005 | -0.63 | .531 | 0.003 | -0.010,  0.016 | 0.007 | 0.41 | .682 | 0.001 | -0.004, 0.003 0.33  0.006 | | | .740 |
| Sample size | <-.001 | <-.001,  <.001 | <.001 | -0.42 | .673 | <-0.001 | <-.001,  <.001 | <.001 | -0.35 | .726 | <.001 | <-.001, <.001 1.51  <.001 | | | .130 |

Articlesfound

viaalternative

sources

*N=7*

Articlesretrieved

fromdatabase

search

*N=*

*26,231*

Articlesafter

duplicatesremoved

*N=23,104*

Duplicatepapers

*N=3,134*

Articlesretainedafter

titlescreening

*N=3*

*96*

Articlesretainedafter

abstractscreening

*N=146*

Articlesretainedafter

fulltextscreening

*N=*

*84*

Articlesincludedin

reviewforquantitative

synthesis

*N=*

*54*

**ArticlesExcluded**

***N=22,708***

Nostressand/oreatingmeasure

*N=*

22,490

Disorderedeating

*N=*

45

Clinicalpopulation

*N=*

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Outsideagerange

*N=*

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Interventionstudy

*N=*

21

NotEnglishlanguage

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Notaresearchpaper

*N=*

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**ArticlesExcluded**

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NoEatingbehaviour

*N=*

120

Nostressmeasure

*N=*

99

Disorderedeating

*N=*

12

Clinicalpopulation

*N=*

5

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3

Interventionstudy

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Animalstudy

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ArticlesExcluded

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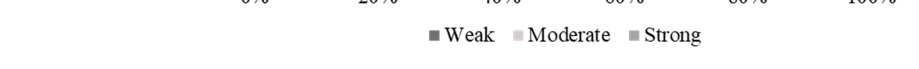
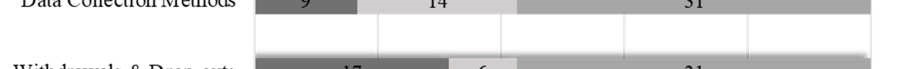
ArticlesExcluded

*N=*

*30*

Figure 1. PRISMA flow diagram indicating articles retained and excluded at each stage of the screening process (Moher, Liberati, Tetzlaff & Altman, 2009).

Figure 2. Number of studies scoring across 5 quality assessment sections from weak to strong



(left to right).



Figure 3. Proportional distribution plot of stress and eating behaviours overall across all studies (*k* = 54).

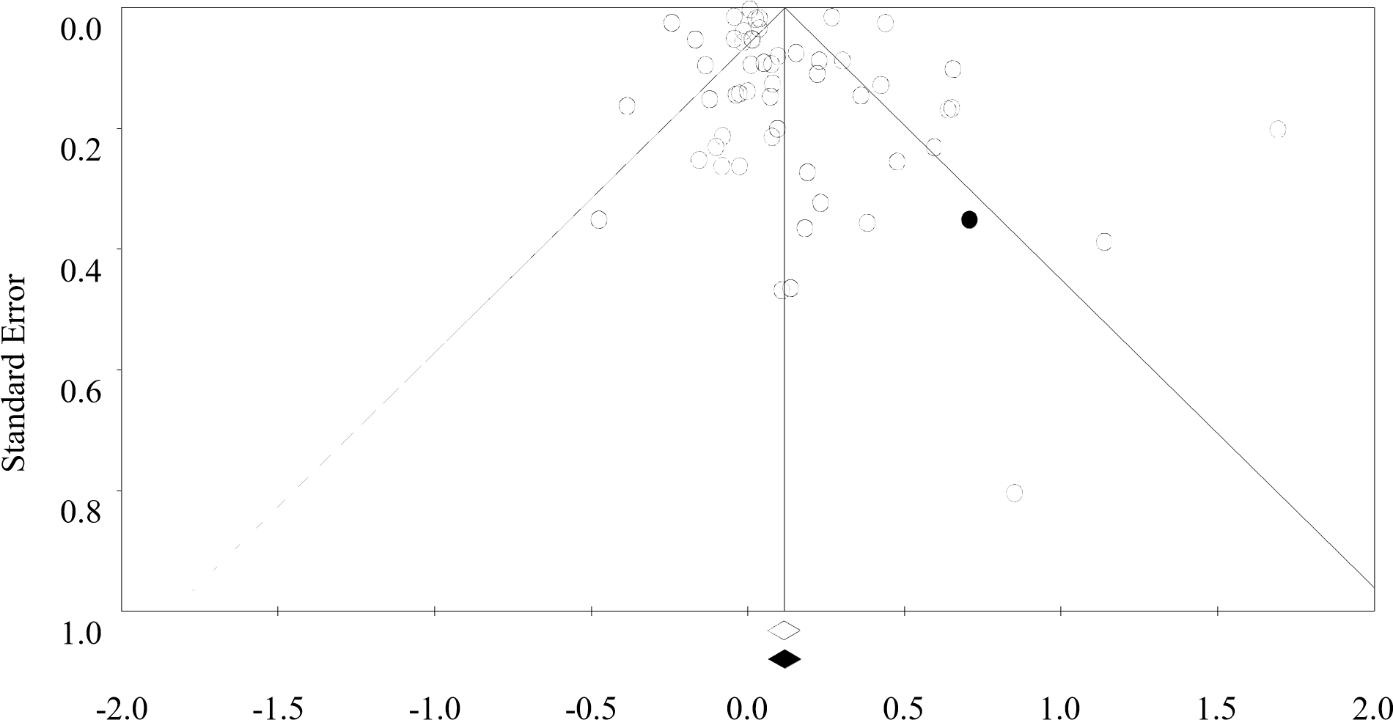
Hedges’ g

Figure 4. Funnel plot of publication bias with observed (white) and imputed (shaded) studies.



Figure 5. Proportional forest plot of stress and consumption of unhealthy foods (*k* = 35).



Figure 6. Proportional forest plot of stress and consumption of healthy foods (*k* =17).

**Supplementary Materials** Item 1. Table of full search terms and an example search strategy.

|  |  |  |  |
| --- | --- | --- | --- |
| **Stress Terms** |  | **Eating Terms** |  |
| 1. Stress\*.mp7. Perceive\* stress    1. ((induce\* adj3 2. Daily adj2   stress) not oxidati\*)  (hassle\* or stress\*)   * 1. cop? adj3 stress\*  1. Hyp?rphagi\*    1. Initiate\* adj2 2. Lab\* adj2   stress\*  stress\*   * 1. Life event\*  1. Acute stress\*    1. Life adj2 stress\* 2. Stress reactiv\* | 1. Food intake.mp   (food intake)   1. Food consum\* 2. Food habit\* 3. Eat\* behavio?r 4. Overeat\* 5. Snack\* 6. Diet\* 7. Eat\* NOT   disorder\* adj2 eat\*   1. Stress adj3 eat\* 2. Diet\* restrain\* 3. Emotion\* eat\* 4. External eat\* 5. Disinhib\* | 1. Healthy adj5   diet   1. Healthy adj2 food\* 2. Convenienceadj3 food\* 3. Healthy adj eat\* 4. Junk adj food\*32. Unhealthy adj eat\* 5. Fat\* 6. Main meal\* 7. Fruit\* 8. Unhealthy adj5 food\* 9. Sugar\* | 1. Vegetable\* 2. Undereat\* 3. Fast adj food\* 4. Calorie\* 5. Kilocalorie\*43. Unhealthy adj5 diet 6. High calorielow nutrient OR   HCLN   1. Low caloriehigh nutrient OR   LCHN |
| **Combined Terms** | | | |
| 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12. | 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or  37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45. | | |
| **13 AND 46** | | | |
| **Notes:** adj = adjective / = map to subject heading **Notes:** adj = adjective  ? = wildcard .mp = title, abstract, subject heading ? = wildcard | | | |

Item 2. Quality assessment tool adapted from the EPHPP (Effective Public Health Practice

Project).

**COMPONENT RATINGS**

# A. SELECTION BIAS

**Q1. Are the individuals selected to participate in the study likely to be representative of the target population?**

1. Very Likely
2. Somewhat Likely
3. Not Likely 4 Can’t Tell

**Q2. What percentage of selected individuals agree to participate?**

1. 80-100% agreement
2. 60-79% agreement
3. Less than 60% agreement
4. Not applicable
5. Can’t tell

|  |  |
| --- | --- |
| **RATE THIS STRONG MODERATE**  **SECTION** | **WEAK** |
| 1 2 | 3 |
| **B. STUDY DESIGN**  **Indicate the study design:**   1. Stress and an objective measure of food intake (multiple time points) 2. Stress and an objective measure of food intake (single time point) 3 Daily diary design 3. Stress and eating measures (multiple time points or longitudinal) 4. Stress and eating measures (single time point) 5. Other. Specify \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ 6. Can’t tell   **Does the study use:**  Independent groups Repeated measures Can’t tell **If independent groups, were all groups of equal size?**  No Yes |  |
| **RATE THIS STRONG MODERATE**  **SECTION** | **WEAK** |
| 1 2 | 3 |

# C. CONFOUNDERS

**Q1. Were additional variables considered in the study?**

1. Yes
2. No
3. Can’t tell

**Examples of confounders:**

Race

Sex

Marital status/family

Age

Socioeconomic Status (e.g., household income, location)

Education

Health Status

**Q2. If yes, indicate the percentage of relevant confounds that were controlled (either in the design (e.g. matching) or analysis).**

1. 80-100% (most)
2. 60-79% (some)
3. Less than 60% (few or none)
4. Can’t tell

|  |  |  |
| --- | --- | --- |
| **RATE THIS SECTION** | **STRONG MODERATE** | **WEAK** |
|  | 1 2 | 3 |
| **D. DATA COLLECTION METHODS**  **Q1. Were data collection tools for stress measurements shown to be valid?**  1 Yes 2 No 3 Can’t tell  **Q2. Were data collection tools for stress measurements shown to be reliable?**  1 Yes 2 No 3 Can’t tell  **Type of eating behaviour measure used:**  Objective Subjective  **Q3. Were data collection tools for eating behaviours shown to be valid?**  1 Yes 2 No 3 Can’t tell  **Q1. Were data collection tools for eating behaviours shown to be reliable?**  1 Yes 2 No 3 Can’t tell | |  |
| **RATE THIS STRONG MODERATE**  **SECTION** | | **WEAK** |
| 1 2 | | 3 |

# E. WITHDRAWALS AND DROPOUTS

**Q1. Were withdrawals and drop-outs reported in terms of number and/or reasons per group?**

1. Yes
2. No
3. Can’t tell
4. Not applicable (i.e. one-time surveys)

**Q2. Indicate the percentage of participants completing the study. (if the percentage differs by groups, record the lowest).**

1. 80-100%
2. 60-79%
3. Less than 60%
4. Can’t tell

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **RATE THIS SECTION** | **STRONG** | **MODERATE** | **WEAK** |  |
|  | 1 | 2 | 3 | Not applicable |

# Global Rating

**Component Ratings**

Please transcribe the information from the grey boxes on pages 1-3 onto this page.

|  |  |  |  |
| --- | --- | --- | --- |
| **A**  **SELECTION BIAS** | **STRONG** | **MODERATE** | **WEAK** |
|  | 1 | 2 | 3 |
| **B**  **STUDY DESIGN** | **STRONG** | **MODERATE** | **WEAK** |
|  | 1 | 2 | 3 |
| **C**  **CONFOUNDERS** | **STRONG** | **MODERATE** | **WEAK** |
|  | 1 | 2 | 3 |
| **D**  **DATA COLLECTION**  **METHOD** | **STRONG** | **MODERATE** | **WEAK** |
|  | 1 | 2 | 3 |
| **E**  **WITHDRAWALS &**  **DROP-OUTS** | **STRONG** | **MODERATE** | **WEAK** |

1 2 3

**GLOBAL RATING FOR THIS PAPER (CIRCLE ONE):**

|  |  |  |
| --- | --- | --- |
| **1** | **STRONG** | (no WEAK ratings) |
| **2** | **MODERATE** | (one WEAK rating) |
| **3** | **WEAK** | (two or more WEAK ratings) |

With both reviewers discussing the ratings:

Is there a discrepancy between the two reviewers with respect to the component (A-E) ratings?

No Yes

If yes, indicate a reason for the discrepancy

1. Oversight
2. Differences in interpretation of criteria 3 Differences in interpretation of study

**Final decision of both reviewers (circle one):**

* 1. **STRONG**
  2. **MODERATE**
  3. **WEAK**

**Scoring Criteria Details**

# A. SELECTION BIAS

**Q1.** Participants are likely to be representative of the target population if they have been recruited from workplaces or from sources away from higher education environments. Studies score 1 (Very likely) if the population have been sourced at random from the population (e.g. selected through online advertisements).

A study may be somewhat likely (score 2) if participants have been recruited from settings other than higher education environments. Studies may score 3 (Not Likely) if the participants are obtained from specific sources (such as undergraduate students, managers of a specific company etc.). Not applicable should be selected for cross-sectional studies carried out at a single time point.

**Q2.** Refers to the number of participants who agreed to complete all parts of the study (i.e. did not drop out).

RATE SECTION:

1. strong = Both Q1 & Q2 are ‘1’, OR Q1 is ‘1’ % Q2 is ‘4’.
2. moderate = Q1 is ‘1’ or ‘2’, and Q2 is ‘1’, ‘2’ OR ‘5’ Can’t tell.
3. weak = Q1 is ‘3’ and Q2 is ‘3’ or ‘4’.

# A. STUDY DESIGN

This section aims to assess the quality of a study based on the type of design used. The overall study design should be indicated, with details on the type of design. If a study used independent groups, please indicate whether groups were of equal size. An allowance of +/-1 participant should be made where sample sizes are odd.

1. **Stress and an objective measure of food intake (multiple time points):** Study includes a measure of objective eating behaviour, such as weighed food intake and 24-hour dietary recall with a dietitian.
2. **Stress and an objective measure of food intake (single time point).**
3. **Daily diary design:** Study adopts a diary design whereby participants are asked to record stress and/or eating habits over multiple days. Minimum number of diary entries required is 2, otherwise study is categorised using one of the below categories. Diaries may be recorded online or on paper.
4. **Stress and subjective eating measures (multiple time points and/or longitudinal):** Study records stress and eating measures at more than one time point (for example one-month part) using the same participants at both/multiple time points. This includes studies which adopt a longitudinal design.
5. **Stress and subjective eating measures (single time point):** Study is cross-sectional, and records stress and eating measures at only one time point.

RATE SECTION:

1. strong = Study design is ‘1’ or ‘2’,
2. moderate = Study design is ‘3’ or ‘4’
3. weak = Study design is ‘5’

# B. CONFOUNDERS

The authors should indicate whether any confounds have been investigated and/or controlled for in the study. Studies may include analyses to compare potential confounding variables (such as age, gender, Socioeconomic status, dietary restraint or BMI). Where there are differences between confounding variables, indicate the estimated percentage that were controlled for in the study (either in the study design, or study analyses).

RATE SECTION:

1. strong = Q1 is ‘2’ OR Q2 is ‘1’
2. moderate = Q1 is ‘1’ AND Q2 is ‘2’
3. weak = Q1 is ‘1’ AND Q2 is ‘3’. OR confounds are not described (Q1 is ‘3’ and Q2 is ‘4’).

# C. DATA COLLECTION METHODS

This section aims to determine whether the comparison and outcome measures are reliable and valid. Indicate whether an objective or subjective method was employed for the measurement of food intake. Reliability and validity may be reported in the study or detailed in a previous study and cited in text. Where objective measures have been used, check whether the method is valid for the purpose of the study (for example, weighed food intake before and after a stress task), and assume reliability.

RATE SECTION:

1. strong = Data collection methods are valid (Q1 / Q3 are ‘1’) AND reliable (Q2 / Q4 are ‘1’). OR an objective measure is used (coded as valid and reliable).
2. moderate = Data collection methods have been shown to be valid (Q1 / Q3 are ‘1’) and have not been shown to be reliable (Q2 / Q4 are ‘2’) or not described (Q2/ Q4 are ‘3’). OR at least one measure (stress / eating) is both valid and reliable.
3. weak = Collection methods have not been shown to be valid (Q1/ Q3 are ‘2’) OR validity and reliability have not been described for both measures (responses are ‘3’ across all questions).

# D. WITHDRAWALS & DROPOUTS

Retention of participants may be reported in the study design (usually under participants) or in the results section. Score YES if the authors note attrition rates and number of dropouts. Score NO if no information is given regarding the number of dropouts or withdrawals in the study. Studies which have used a single time point should be coded as 4 (Not applicable) and counted as ‘strong’ in global rating on withdrawals and dropouts for that paper. The percentage of participants completing the study refers to the number of participants retained for data analysis.

1. strong = where retention is 80% or greater (Q1 is ‘1’ and Q2 is ‘1’).
2. moderate = where retention is no lower than 60% (Q1 is ‘1’ and Q2 is ‘2’).
3. weak = where follow up rates are less than 60% (Q1 is ‘1’ and Q2 is ‘3’, or if withdrawals / dropouts have not been described (Q1 is ‘3’ and Q2 is ‘4’).

Not applicable = Where studies have used a single time point (e.g. a one-time survey).

Item 3. Reference list of studies inlcuded in the meta-analysis.

Algren, M. H., Ekholm, O., Nielsen, L., Ersbøll, A. K., Bak, C. K., & Andersen, P. T. (2018). Associations between perceived stress, socioeconomic status, and health-risk behaviour in deprived neighbourhoods in Denmark: a cross-sectional study. *BMC Public Health, 18*(1), 250. doi: 10.1186/s12889-018-5170-x

Appelhans, B. M. (2010). Circulating leptin moderates the effect of stress on snack intake independent of body mass. *Eating Behaviors, 11*(3), 152-155. doi:

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Barrington, W. E., Beresford, S. A., McGregor, B. A., & White, E. (2014). Perceived stress and eating behaviors by sex, obesity status, and stress vulnerability: findings from the vitamins and lifestyle (VITAL) study. *Journal of the Academy of Nutrition and Dietetics, 114*(11), 1791-1799. doi: 10.1016/j.jand.2014.03.015

Barrington, W. E., Ceballos, R. M., Bishop, S. K., McGregor, B. A., & Beresford, S. A. (2012). Perceived stress, behavior, and body mass index among adults participating in a worksite obesity prevention program, Seattle, 2005–2007. *Preventing Chronic Disease, 9*(E152). doi: 10.5888/pcd9.120001

Boggiano, M. M., Wenger, L. E., Turan, B., Tatum, M. M., Sylvester, M. D., Morgan, P. R., . . . Burgess, E. E. (2015). Real-time sampling of reasons for hedonic food consumption: further validation of the Palatable Eating Motives Scale. *Frontiers in Psychology, 6*, 744. doi: 10.3389/fpsyg.2015.00744

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Dweck, J. S., Jenkins, S. M., & Nolan, L. J. (2014). The role of emotional eating and stress in the influence of short sleep on food consumption. *Appetite, 72*, 106-113. doi: 10.1016/j.appet.2013.10.001

El Ansari, W., Adetunji, H., & Oskrochi, R. (2014). Food and mental health: relationship between food and perceived stress and depressive symptoms among university students in the United Kingdom. *Central European Journal of Public Health, 22*(2), 90-97. doi: 10.21101/cejph.a3941

El Ansari, W., & Berg-Beckhoff, G. (2015). Nutritional correlates of perceived stress among University Students in Egypt. *International Journal of Environmental Research and*

*Public Health, 12*(11), 14164-14176. doi: 10.3390/ijerph121114164

El Ansari, W., Suominen, S., & Berg-Beckhoff, G. (2015). Mood and food at the University of Turku in Finland: nutritional correlates of perceived stress are most pronounced among overweight students. *International Journal of Public Health, 60*(6), 707-716. doi: 10.1007/s00038-015-0717-4

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10.1016/j.eatbeh.2016.06.008

Groesz, L. M., McCoy, S., Carl, J., Saslow, L., Stewart, J., Adler, N., . . . Epel, E. (2012).

What is eating you? Stress and the drive to eat. *Appetite, 58*(2), 717-721. doi: 10.1016/j.appet.2011.11.028

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Järvelä-Reijonen, E., Karhunen, L., Sairanen, E., Rantala, S., Laitinen, J., Puttonen, S., . . . Myllymäki, T. (2016). High perceived stress is associated with unfavorable eating behavior in overweight and obese Finns of working age. *Appetite, 103*, 249-258. doi: 10.1016/j.appet.2016.04.023

Klatzkin, R. R., Dasani, R., Warren, M., Cattaneo, C., Nadel, T., Nikodem, C., & Kissileff, H. R. (2019). Negative affect is associated with increased stress-eating for women with high perceived life stress. *Physiology and Behavior, 210*, 112639. doi: 10.1016/j.physbeh.2019.112639

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Newman, E., O’Connor, D. B., & Conner, M. (2007). Daily hassles and eating behaviour: the role of cortisol reactivity status. *Psychoneuroendocrinology, 32*(2), 125-132. doi: 10.1016/j.psyneuen.2006.11.006

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Item 4. Summary of descriptives for studies included in review (*k*=54).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Author(s) and Year** | **Sample**  **Size** | **Gender** | **Mean age and BMI** | **Stress Category** | **Eating Behaviour**  **Measurement** | **Eating Behaviour**  **Category** |
| Algren et al. (2018) | 14,686 | 7,955 females  (54.2%)  6,731 males | Mean age and BMI  not reported | Perceived | Weekly fruit and vegetable intake[[2]](#footnote-2) | Other |
| Appelhans (2010) | 34 | All female | 33.5 years  27.7 kg/m[[3]](#footnote-3) | Induced | Objectively measured snack intake2 | Other |
| Barker, Blain, and  Russell (2015) | 20 | All male | 20 years  (median age)  BMI not reported | Induced | 24-hour dietary recall[[4]](#footnote-4) | Other |
| Barrington et al. (2014)3 | 65,235 | 32,880 females  (50.4%)  32,355 males | Not reported | Perceived | Food frequency[[5]](#footnote-5) | Healthy and  Unhealthy |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Barrington et al. (2012)[[6]](#footnote-6) | 621 | 357 females  (57.5%)  264 males | Mean age not  reported  29.2 kg/m2 | Perceived | Food frequency[[7]](#footnote-7) | Healthy and  Unhealthy |
| Boggiano et al. (2015) | 169 | 106 females  (62.7%)  63 males | 21.1 years  27.5 kg/m2 | Perceived  (daily diary) | Food frequency[[8]](#footnote-8) | Unhealthy |
| Boyce and Kuijer (2015) | 175 | 121 females  (69%)  54 males | 18.2 years  23.8 kg/m2 | Perceived | Food frequency[[9]](#footnote-9) | Healthy and  Unhealthy |
| Carson et al. (2015) | 355 | All female | 49.8 years  36.5 kg/m2 | Perceived | 24-hour dietary recall[[10]](#footnote-10) | Unhealthy and  Other |
| Conner, Fitter and  Fletcher (1999) | 60 | 33 females  (55%)  27 males | 20 years  Mean BMI not  reported | Perceived  (daily diary) | Between-meal snacks10 | Other |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Crowther, Sanftner,  Bonifazi, and Shepherd  (2001) | 17 | All female | 18.8 years  20.2 kg/m2 | Perceived  (daily hassles) | Food frequency[[11]](#footnote-11) | Other |
| Dweck, Jenkins, and  Nolan (2014)  Experiment 2 | 64 | All female | 18.8 years  24.5 kg/m2 | Induced | Objectively measured snack intake[[12]](#footnote-12) | Other |
| El Ansari, Adetunji, and  Oskrochi (2014)[[13]](#footnote-13) | 3,706 | 2,699 females  (72.8%)  765 males  242 not reported | 24.9 years  Mean BMI not  reported | Perceived | Food frequency[[14]](#footnote-14) | Healthy, unhealthy and other |
| El Ansari and Berg-  Beckhoff (2015) | 2,810 | 1,483 females  (52.8%)  1,327 males | 18 years  Mean BMI not  reported | Perceived | Food frequency[[15]](#footnote-15) | Healthy and  Unhealthy |

El Ansari, Suominen, and 1,076 762 females 21 years (median Perceived Food frequency16 Healthy and

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Berg-Beckhoff (2015) |  | (70.8%)  314 males | age)  Mean BMI not  reported |  |  | unhealthy |
| Errisuriz, Pasch, and  Perry (2016) | 613 | 368 females  (60%)  245 males | 18.9 years  23.0 kg/m2 | Perceived | Food frequency[[16]](#footnote-16) | Healthy, unhealthy and other |
| Groesz et al. (2012)[[17]](#footnote-17) | 457 | All female | 28.5 years  24.2 kg/m2 | Perceived | Food frequency[[18]](#footnote-18) | Healthy and unhealthy |
| Habhab, Sheldon and  Loeb (2009) | 40 | All female | 21.35 years  23.17 kg/m2 | Induced | Objectively measured food intake[[19]](#footnote-19) | Other |
| Heatherton, Herman and  Polivy (1991) | 75 | All female | Not reported | Induced | Objectively measured food intake[[20]](#footnote-20) | Unhealthy |
| Herhaus, Päßler, and  Petrowski (2018) | 56 | 30 females  (53.6%) | 32.86 years  27.7 kg/m2 | Induced | Objectively measured food intake[[21]](#footnote-21) | Unhealthy |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | 26 males |  |  |  |  |
| Horton, Timmerman and  Brown (2018) | 251 | 194 females  (77.6%)  56 males | 20.49 years  Mean BMI Not  reported | Perceived | Fat intake[[22]](#footnote-22) | Unhealthy |
| Järvelä-Reijonen et al.  (2016) | 297 | 249 females  (83.8%)  48 males | 48.9 years  31.3 kg/m2 | Perceived | 48-hour dietary recall  (self-reported)[[23]](#footnote-23) | Unhealthy |
| Klatzkin et al. (2019) | 43 | All female | 19.5 years  23.4 kg/m2 | Induced | Objectively measured food intake24 | Unhealthy |
| Kwan and Gordon (2016)  Study 2 | 156 | All female | 19.27 years  Mean BMI not  reported | Induced | Objectively measured food intake[[24]](#footnote-24) | Unhealthy |
| Lai, Why, Koh, Ng, and  Lim (2012) | 48 | All female | 19.9 years  20.7 kg/m2 | Induced | 3-day food diary25 | Other |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Lattimore (2001)[[25]](#footnote-25) | 9 | All female | 24 years  22 kg/m2 | Induced | Objectively measured food intake[[26]](#footnote-26) | Unhealthy |
| Lemmens, Rutters, Born, and Westerterp-Plantenga  (2011) | 42 | 26 females  (61.9%)  16 males | 30.7 years  25.4 kg/m2 | Induced | Objectively measured food intake[[27]](#footnote-27) | Other |
| Levine and Marcus  (1997) | 20 | All female | 18.4 years  22.2 kg/m2 | Induced | Objectively measured food intake22 | Unhealthy |
| Liu et al. (2007) | 2,541 | 1,071 females  (42.1%)  1,470 males | 20.4 years  Mean BMI not  reported | Perceived | Food frequency[[28]](#footnote-28) | Healthy, unhealthy and other |
| Mouchacca et al. (2013) | 1,382 | All female | 35.7 years  26.2 kg/m2 | Perceived | Food frequency[[29]](#footnote-29) | Unhealthy |
| Nelson, Lust, Story &  Ehlinger (2008)[[30]](#footnote-30) | 3,206 | 1,956 females  (61%) | 24.2 years Mean BMI not | Perceived | Food frequency32 | Unhealthy |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | 1[[31]](#footnote-31),250 males | reported |  |  |  |
| Newman et al. (2007) | 50 | All female | 34.0 years  23.3 kg/m2 | Perceived | Between-meal snacks10 | Other |
| Ng and Jeffery (2003)33 | 12,110 | 6,620 females  (54.6%)  5,490 males | 40.0 years  BMI not reported | Perceived | Food frequency[[32]](#footnote-32) | Unhealthy |
| O'Connor et al. (2008) | 422 | 229 females  (54.3%)  193 males | 40.32 years  25.6 kg/m2 | Perceived  (daily diary) | Between-meal snacks[[33]](#footnote-33) | Healthy, unhealthy and other |
| O'Connor and O'Connor  (2004) | 155 | All female | 21.12 years  22.8 kg/m2 | Perceived  (daily diary) | Between-meal snacks[[34]](#footnote-34) | Unhealthy and other |
| Oliver et al. (2000) | 68 | 41 females  (60.3%)  27 males | 26.1 years  22.1 kg/m2 | Induced | Objectively measured food intake[[35]](#footnote-35) | Other |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Pak, Olsen, and Mahoney  (1999) | 207 | 137 females  (66.2%)  70 males | 48 years  BMI not reported | Perceived | Food frequency[[36]](#footnote-36) | Healthy and other |
| Papier, Ahmed, Lee, and  Wiseman (2015)[[37]](#footnote-37) | 728 | 397 females  (54.5%)  331 males | 21.35 years  Mean BMI not  reported | Perceived | Food frequency40 | Healthy, unhealthy and other |
| Pelletier, Lytle, and  Laska (2016) | 441 | 298 females  (67.6%)  143 males | Mean age and mean  BMI not reported | Perceived | Food frequency41 | Unhealthy and other |
| Pollard, Steptoe, Canaan,  Davies, and Wardle  (1995) | 115 | 51 females  (44.4%)  64 males | 22.25 years  24.1 kg/m2 | Induced | 24-hour dietary recall[[38]](#footnote-38) | Other |

Raspopow, Abizaid, 48 All female 19.28 years Induced Objectively measured Other

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Matheson, and Anisman  (2010) |  |  | 23.9 kg/m2 |  | food intake[[39]](#footnote-39) |  |
| Raspopow, Abizaid,  Matheson, and Anisman  (2014) | 66 | All female | 20.5 years  Mean BMI not  reported | Induced | Objectively measured food intake[[40]](#footnote-40) | Unhealthy |
| Roberts et al. (2014) | 38 | All female | 42.0 years  24.9 kg/m2 | Perceived | Food frequency[[41]](#footnote-41) | Unhealthy and other |
| Roohafza et al. (2007)46 | 5,892 | 2,915 females  (49.5%)  2,917 males  60 not reported | 40.5 years  BMI not reported | Perceived | Food frequency[[42]](#footnote-42) | Healthy |
| Rutters, Nieuwenhuizen,  Lemmens, Born and  Westerterp-Plantenga | 129 | 1. females   (49.6%)   1. males | 27.6 years  24.5 kg/m2 | Induced | Objectively measured food intake[[43]](#footnote-43) | Other |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| (2009) |  |  |  |  |  |  |
| Steptoe, Lipsey, and  Wardle (1998) | 44 | 28 females  (63.6%)  16 males | 41.8 years  BMI not reported | Perceived  (daily diary) | Food frequency[[44]](#footnote-44) | Healthy, unhealthy and other |
| Stone and Brownell  (1994) | 158 | 79 females  (50% female)  79 males | 43.2 years  BMI not reported | Perceived  (daily diary) | Food frequency[[45]](#footnote-45) | Other |
| van Strien, Roelofs, and de Weerth (2013) | 46 | All female | 19.7 years  21.3 kg/m2 | Induced | Objectively measured food intake43 | Other |
| Vidal et al. (2018) | 523 | 272 females  (52%)  251 males | 19.0 years  BMI not reported | Perceived | Food frequency[[46]](#footnote-46) | Unhealthy |
| Wallis and Hetherington  (2004) | 38 | All female | 24.4 years  24.1 kg/m2 | Induced | Objectively measured food intake[[47]](#footnote-47) | Unhealthy |

Wallis and Hetherington 26 All female 27.4 years Induced Objectively measured Unhealthy

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| (2009) Study 2 |  |  | 24.3 kg/m2 |  | food intake[[48]](#footnote-48) |  |
| Wardle et al. (2000) | 82 | 53 females  (64.4%)  29 males | 35.0 years  25.0 kg/m2 | Perceived | 24-hour dietary recall53 | Unhealthy and other |
| Zellner et al. (2006)  Experiment 1 | 34 | All female | 22.0 years  BMI not reported | Induced | Objectively measured food intake54 | Healthy, unhealthy and other |
| Zellner, Saito, and  Gonzalez (2007) | 36 | All male | 20 years  BMI not reported | Induced | Objectively measured food intake54 | Healthy, unhealthy and other |
| Zenk et al. (2014) | 100 | All female | 44.3 years  BMI not reported | Perceived | Between-meal snacks11 | Other |

Item 5. Descriptions of sample types and stress measures for studies included in review (*k*=54).

|  |  |  |
| --- | --- | --- |
| **Author(s) and Year** | **Sample Source** | **Stress Measure Type** |
| Algren et al. (2018) | General population | Perceived Stress Scale  (Cohen, Kamarck &  Mermelstein, 1983) |
| Appelhans (2010) | Unclear | Modified Trier Social  Stress Task (Kirschbaum,  Pirke, & Hellhammer, 1993) |
| Barker, Blain, and Russell (2015) | University students | Academic examinations |
| Barrington et al. (2014) | General population | Perceived stress |
| Barrington et al. (2012) | Occupational cohort | Perceived Stress Scale (Cohen et al., 1983) |
| Boggiano et al. (2015) | University students | Perceived stress |
| Boyce and Kuijer (2015) | University students | Perceived stress |
| Carson et al. (2015) | General population | Perceived Stress Scale (Cohen et al., 1983) |
| Conner, Fitter and Fletcher (1999) | University students | Daily diary |
| Crowther, Sanftner,  Bonifazi, and Shepherd  (2001) | University students | Hassles Scale (DeLongis, Folkman, & Lazarus, 1988) |
| Dweck, Jenkins, and  Nolan (2014)  Experiment 2 | University students | Unsolvable Sudoku puzzle |
| El Ansari, Adetunji, and Oskrochi (2014) | University students | Perceived Stress Scale (Cohen et al., 1983) |
| El Ansari and BergBeckhoff (2015) | University students | Perceived Stress Scale (Cohen et al., 1983) |
| El Ansari, Suominen, and Berg-Beckhoff (2015) | University students | Perceived Stress Scale (Cohen et al., 1983) |
| Errisuriz, Pasch, and | University students | Perceived stress |

|  |  |  |
| --- | --- | --- |
| Perry (2016) |  |  |
| Groesz et al. (2012) | General population | Perceived Stress Scale (Cohen et al., 1983) |
| Habhab, Sheldon and Loeb (2009) | University students | Unsolvable Sudoku puzzle |
| Heatherton, Herman and Polivy (1991) | University students | Speech, shock and failure tasks |
| Herhaus, Päßler, and Petrowski (2018) | General population | Trier Social Stress Task (Kirschbaum et al.,1993) |
| Horton, Timmerman and Brown (2018) | General population | Perceived Stress Scale (Cohen et al., 1983) |
| Järvelä-Reijonen et al. (2016) | General population | Perceived Stress Scale (Cohen et al., 1983) |
| Klatzkin et al. (2019) | University students | Trier Social Stress Task (Kirschbaum et al.,1993) |
| Kwan and Gordon (2016)  Study 2 | University students | Speech task |
| Lai, Why, Koh, Ng, and Lim (2012) | University students | Academic examinations |
| Lattimore (2001) | University students | Ego-threatening Stroop task |
| Lemmens, Rutters, Born, and Westerterp-  Plantenga (2011) | General population | Unsolvable math task |
| Levine and Marcus (1997) | University students | Speech task |
| Liu et al. (2007) | University students | Perceived stress |
| Mouchacca et al. (2013) | General population | Perceived Stress Scale (Cohen et al., 1983) |
| Nelson, Lust, Story & Ehlinger (2008) | University students | Perceived stress |
| Newman et al. (2007) | General population | Daily hassles |
| Ng and Jeffery (2003) | Occupational cohort | Perceived Stress Scale (Cohen et al., 1983) |
| O'Connor et al. (2008) | Occupational cohort | Daily hassles |

|  |  |  |
| --- | --- | --- |
| O'Connor and O'Connor (2004) | University students | Daily hassles |
| Oliver et al. (2000) | University students & staff | Speech task |
| Pak, Olsen, and Mahoney (1999) | Occupational cohort | Perceived stress |
| Papier, Ahmed, Lee, and Wiseman (2015) | University students | Depression Anxiety Stress  Scale (stress scale only;  Crawford & Henry, 2003) |
| Pelletier, Lytle, and Laska (2016) | University students | Perceived Stress Scale  (Cohen & Williamson, 1988) |
| Pollard, Steptoe, Canaan,  Davies, and Wardle  (1995) | University students | Academic examinations |
| Raspopow, Abizaid,  Matheson, and Anisman  (2010) | University students | Trier Social Stress Task (Kirschbaum et al.,1993) |
| Raspopow, Abizaid,  Matheson, and Anisman  (2014) | University students | Trier Social Stress Task (Kirschbaum et al.,1993) |
| Roberts et al. (2014) | University students | Academic examinations |
| Roohafza et al. (2007) | General population | General Health Questionnaire (Goldberg, 1992) |
| Rutters, Nieuwenhuizen,  Lemmens, Born and  Westerterp-Plantenga  (2009) | Unclear | Unsolvable math task |
| Steptoe, Lipsey, and Wardle (1998) | Occupational cohort | Perceived Stress Scale (Cohen et al., 1983) |
| Stone and Brownell (1994) | General population | Daily hassles |
| van Strien, Roelofs, and de Weerth (2013) | University students | Trier Social  Stress Task (Kirschbaum et al.,1993) |
| Vidal et al. (2018) | University students | Perceived Stress Scale (Cohen et al., 1983) |
| Wallis and Hetherington (2004) | University students | Ego-threatening Stroop task |

|  |  |  |
| --- | --- | --- |
| Wallis and Hetherington (2009) Study 2 | General population | Ego-threatening Stroop task |
| Wardle et al. (2000) | Occupational cohort | Perceived Stress Scale (Cohen et al., 1983) |
| Zellner et al. (2006) Experiment 1 | University students | Unsolvable anagrams |
| Zellner, Saito, and Gonzalez (2007) | University students | Unsolvable anagrams |
| Zenk et al. (2014) | General population | Daily hassles |

Item 6. PRISMA Checklist.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Section/topic | # | Checklist item | Reported page # | on |
| TITLE |  |  |  |  |
| Title | 1 | Identify the report as a systematic review, meta-analysis, or both. | 1 |  |
| ABSTRACT | |  |  |  |
| Structured summary | 2 | Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number. | 2 |  |
| INTRODUCTION | |  |  |  |
| Rationale | 3 | Describe the rationale for the review in the context of what is already known. | 3-9 |  |
| Objectives | 4 | Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS). | 8-9 |  |
| METHODS | |  |  |  |
| Protocol and  registration | 5 | Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number. | 10 |  |
| Eligibility criteria | 6 | Specify study characteristics (e.g., PICOS, length of followup) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale. | 10-12 |  |
| Information sources | 7 | Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched. | 10 | |
| Search | 8 | Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated. | Supplementary materials, page 1 | |
| Study selection | 9 | State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis). | 10-12 | |
| Data collection process | 10 | Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators. | 14-15 | |
| Data items | 11 | List and define all variables for which data were sought  (e.g., PICOS, funding sources) and any assumptions and | 12-14 | |

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | simplifications made. |  |
| Risk of bias in individual studies | 12 | Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis. | 15-16 |
| Summary measures | 13 | State the principal summary measures (e.g., risk ratio, difference in means). | 15-16 |
| Synthesis of  results | 14 | Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I2) for each meta-analysis. | 15-16 |
| Risk of bias  across studies | 15 | Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies). | 15-16 |
| Additional analyses | 16 | Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified. | 15-16 |
| RESULTS |  |  |  |
| Study selection | 17 | Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram. | 16-17 & 56 |
| Study  characteristics | 18 | For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations. | Supplementary materials, pages 15-30 |
| Risk of bias  within studies | 19 | Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12). | 19 & 59 |
| Results of  individual studies | 20 | For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot. | 18-25 & 51-55  & 58-61 |
| Synthesis of  results | 21 | Present results of each meta-analysis done, including confidence intervals and measures of consistency. | 18-25 |
| Risk of bias  across studies | 22 | Present results of any assessment of risk of bias across studies (see Item 15). | 19 |
| Additional analysis | 23 | Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]). | 19-25 |
| DISCUSSION | |  |  |
| Summary of  evidence | 24 | Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers). | 25-32 |
| Limitations | 25 | Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias). | 30-31 |

|  |  |  |  |
| --- | --- | --- | --- |
| Conclusions | 26 | Provide a general interpretation of the results in the context of other evidence, and implications for future research. | 33 |
| FUNDING |  |  |  |
| Funding | 27 | Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review. | 1 |

1. As a sub-group within perceived stress, analyses indicated that use of a daily diary methodology yielded a strong, significant effect, *Hedges’ g* = 0.313, *95%CIs* [0.160, 0.465], *Z =* 4.003, *p* < .001\*\*. [↑](#footnote-ref-1)
2. Analyses were based on low intake fruit/vegetable (i.e., respondents who did not eat fruit or vegetables every week). [↑](#footnote-ref-2)
3. Intake measured by total intake (kcal). [↑](#footnote-ref-3)
4. Results adjusted for age, sex, race, education, marital status and perceived stress. [↑](#footnote-ref-4)
5. Servings per week of high fat snacks, fast food items, fruits and vegetables. [↑](#footnote-ref-5)
6. Results controlled for age, sex, race, education and worksite. [↑](#footnote-ref-6)
7. Portions of fruit and vegetables per day, and number of fast food meals consumed per week. [↑](#footnote-ref-7)
8. Total number of unhealthy foods consumed over four days. [↑](#footnote-ref-8)
9. Portions of fruit and vegetables per day, and number of days per week consumed fast/junk foods or overate when full. [↑](#footnote-ref-9)
10. Intake of total fat (grams) categorised as unhealthy. Total energy intake (kcals), carbohydrates (grams) and protein (grams) categorised as other foods. 10 Number of snacks consumed. [↑](#footnote-ref-10)
11. Total calories consumed per day. [↑](#footnote-ref-11)
12. Total calories consumed of both healthy and unhealthy snack foods. [↑](#footnote-ref-12)
13. Controlled for University. [↑](#footnote-ref-13)
14. Eating behaviour category was based on food groupings used e.g., fresh fruits (healthy), sweets (unhealthy) and snacks / products based on macronutrients

    (other). [↑](#footnote-ref-14)
15. Composite food intake scores (healthy and unhealthy patterns) based on self-reported food frequency. [↑](#footnote-ref-15)
16. Portions per day of fruit and vegetables (healthy). Servings per week of fast foods, sweet / salty snacks (unhealthy) and frozen foods (other). [↑](#footnote-ref-16)
17. Results controlled for age, BMI, education and income. [↑](#footnote-ref-17)
18. Consumption of nutritious foods (healthy) and palatable, non-nutritious foods (unhealthy). [↑](#footnote-ref-18)
19. Total consumption (ounces) of high/low fat sweet and salty foods. [↑](#footnote-ref-19)
20. Grams of ice cream eaten. [↑](#footnote-ref-20)
21. Total intake (kcal) of unhealthy foods. [↑](#footnote-ref-21)
22. Fat intake was measured using the Block Dietary Fat Screener (Block, Gillespie, Rosenbaum & Jenson, 2000). Higher scores indicate more calories from fat intake. [↑](#footnote-ref-22)
23. Consumption of food groups e.g., vegetables (healthy), pastries (unhealthy) and rye bread (other) in grams per day. 24 Total calories consumed of high fat snacks. [↑](#footnote-ref-23)
24. Energy intake in calories per day. [↑](#footnote-ref-24)
25. Mean age and BMI for whole sample (N=20). Meta-analysis included only none binge eating participants from the study (N=9). [↑](#footnote-ref-25)
26. Total calories consumed of full fat ice cream. [↑](#footnote-ref-26)
27. Total energy intake as a percentage of daily energy requirements. [↑](#footnote-ref-27)
28. Consumption of food groups including fruit (healthy), fast food (unhealthy) and snack food (other). [↑](#footnote-ref-28)
29. Consumption of unhealthy food groups including pizza and chocolates (unadjusted data obtained). [↑](#footnote-ref-29)
30. Results adjusted for gender, age, race and hours worked per week. [↑](#footnote-ref-30)
31. Food frequency coded into intake of less than 5 servings of fruit and vegetables per day and consumption of fast food. 33 Results controlled for age, education, ethnicity and marital status. [↑](#footnote-ref-31)
32. Consumption of high fat foods only. [↑](#footnote-ref-32)
33. Daily consumption of fruit/vegetables (healthy), high fat/sugar snacks (unhealthy) and total snacks (other). [↑](#footnote-ref-33)
34. Consumption of unhealthy snacks (chocolate/savoury/biscuits) and mean snack consumption (other). [↑](#footnote-ref-34)
35. Total energy intake (kcal) of high and low fat sweet, salty and bland foods. [↑](#footnote-ref-35)
36. Frequency of meals/fruit consumption (healthy) and eating out/snacks/caffeine (other). [↑](#footnote-ref-36)
37. Data were adjusted for academic group, marital status, working hours, living situation, BMI, dieting, frequency of exercise and smoking status. 40 Consumption of food groups e.g., vegetables and fruit (healthy), highly processed foods (unhealthy) and cereal foods (other). 41 Consumption of fast food per week (unhealthy) and snacks per day (other). [↑](#footnote-ref-37)
38. Total energy intake (kcal). [↑](#footnote-ref-38)
39. Consumption of high and low-fat snacks (calories). [↑](#footnote-ref-39)
40. Consumption of a high fat snack (brownies) in grams. [↑](#footnote-ref-40)
41. Food frequency categorised into macronutrients e.g., fat (unhealthy) and protein (other). Also included total calories consumed (other). 46 Results adjusted for age, gender, education and marriage. [↑](#footnote-ref-41)
42. Fruit and vegetable consumption per day. [↑](#footnote-ref-42)
43. Total energy intake of sweet and salty foods (kJ). [↑](#footnote-ref-43)
44. Daily consumption of food groups over 8 weeks e.g., fresh fruit (healthy), sweet foods (unhealthy) and red meat (other). [↑](#footnote-ref-44)
45. Measured as a change in food consumption (eating more or less than usual). [↑](#footnote-ref-45)
46. Fat intake measured through the Block Screening Questionnaire for Fat Intake (Thompson & Byers, 1994). [↑](#footnote-ref-46)
47. Consumption in grams of high fat/sugar snack foods. [↑](#footnote-ref-47)
48. Consumption of macronutrients e.g., saturated fat in grams (unhealthy), carbohydrates and total energy intake in calories (other). 54 Total intake (grams) of high and low-fat snacks. [↑](#footnote-ref-48)