Psychological, Social, and Behavioural Mediators of the Link Between Obesity and Depression in Childhood and Adolescence: A Systematic Review and Meta-Analysis

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Abstract

Young people with obesity are significantly more likely to experience depression than their lower weight peers (Quek et al., 2017; Sutaria et al., 2019). This is problematic, as both conditions track into adulthood (Alberga et al., 2012; Thapar et al., 2012) and their comorbidity is associated with poor health and treatment outcomes (McElroy, 2015). The mechanisms through which obesity may contribute to depression are poorly understood. Uncovering these processes could provide targets for treatment and prevention that would improve outcomes for children and youth in larger bodies. The purpose of this systematic review and meta-analysis was to identify these mechanisms, by synthesizing and critically appraising the scientific evidence examining psychological, social, and behavioural mediators of the link between weight status and depressive symptoms in this population. *Methods*: MEDLINE, CINAHL, PsycINFO, and PubMed were systematically searched using a peer-reviewed strategy. Eligible reports used formal mediation analysis or causal modelling to assess the impact of any psychological, social, and/or behavioural variable(s) on the association between weight status and depressive symptoms in children and youth between five and 18 (22) years. Clinical samples and intervention trials were excluded. Quantitative (random-effects meta-regressions and subgroup analysis) and qualitative (statistical vote counting) methods were employed to synthesize the body of evidence for each outcome, the strength of which was rated using a structured framework. *Results*: 19 reports were included, yielding 43 effects eligible for inclusion in quantitative and/or qualitative synthesis. Results identified a small, statistically significant average indirect effect of all investigated mediators. Gender did not significantly moderate mediation pathways, with many mechanisms showing similar strength of effect for boys and girls. Insufficient evidence was available with which to evaluate developmental stage and culture

as moderators of mediation pathways. Partial support was found for the validity of the *gender additive model of depression* (GAM; Stice & Bearman, 2001) in explaining the link between weight status and depression: a small, statistically significant effect was found for GAM variables, though no effects were reported for 'pressure to be thin' or 'thin ideal internalization' and effects were not significantly different than those of non-GAM variables. Cognitive, social, and behavioural mediators were found to have similar magnitudes of effect, suggesting that clinical assessment and intervention target all three of these areas. Body dissatisfaction, teasing, and dieting were highlighted as individual mediators warranting clinical attention, though the strength of this evidence was generally rated low, signalling a need for further research in this area.

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children and youth of all body types – may you continue to bravely build a world that embraces our differences, where we value the size of our hearts, and not the size of our bodies.

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Introduction

Overview and Objective

Obesity and depression are both public health concerns with real implications for the well-being of children and adolescents. Global rates of childhood obesity have been increasing dramatically, with numbers expected to reach 206 million children by 2025 (Lobstein & Brinsden, 2019). A parallel rise in depression among young people since the early 2000s is also sounding alarm bells (Daly, 2022). Children and youth in larger bodies may be particularly vulnerable to experiencing depression and other mental health issues compared to their normal weight peers (Lindberg et al., 2020; W.-W. Rao et al., 2020). Youth presenting for weight-related treatment experience mental health difficulties with such frequency their co-occurrence has been referred to as an 'epidemic within an epidemic' (McElroy, 2015). Some evidence suggests this risk may be particularly elevated for certain groups of individuals, including females (Godina-Flores et al., 2023). Comorbidity of overweight/obesity and depression is associated with a more severe course of illness and poorer outcomes, including impaired functioning and reduced quality of life (McElroy, 2015). It may also limit engagement in health promoting behaviours and treatment (Jensen et al., 2012; M. Zeller et al., 2004). Exactly how weight status contributes to the development of depressive symptoms is unclear. While genetic and biological processes play a role (Fulton et al., 2022), the increasing prevalence of both conditions at earlier ages suggests the role of psychological, social, and behavioural influences. A body of research seeking to uncover the nature of these influences has been amassed over the last several decades, though findings are often disparate and lack theoretical underpinning. This dissertation, presented in monograph form, seeks to better understand the ways through which weight status influences the development of depression in children and adolescents. A systematic review and meta-analysis

were conducted to systematically identify, synthesize, and critically appraise the scientific evidence investigating potential psychological, social, and behavioural mediators of this relationship. Findings will serve to inform prevention and treatment efforts to improve mental health outcomes for young people in larger bodies. First, a review of the literature is presented through which to frame this investigation.

Literature Review

Obesity in Children and Adolescents

Definition and Assessment

"Obesity" is a medical term used to describe a condition wherein excess fat accumulation in the body increases the risk for adverse health outcomes (Javed et al., 2015). Notably, it does not require the presence of any comorbidities or complications, but merely an increased risk of their occurrence (Purnell, 2000). Hence, a cornerstone of diagnosis is the measurement of body fat – though measured in isolation without further evaluation of risk, is considered insufficient (World Health Organization, 2021). Several methods for the assessment body fat exist, many of which are impractical or even impossible in the context of clinical settings (Purnell, 2000; Visscher et al., 2009). Techniques include but are not limited to waist circumference measurement, dual-energy X-ray absorptiometry, air-displacement plethysmography and skin-fold thickness measurement (Javed et al., 2015; Visscher et al., 2009). By far the most common method (Katzmarzyk et al., 2007; Visscher et al., 2009) is known as Body Mass Index (BMI), which is calculated by dividing an individual's weight in kilograms by their height in meters squared (kg/m^2). In adults, BMI cut-offs have been established to delineate weight categories based on their degree of associated health risks, where a BMI of 25 kg/m^2 is the threshold for

overweight and 30 kg/m^2 is the threshold for obesity (CDC, 2022a). BMI is straightforward to measure and calculate, associated with other measures of adiposity, and recommended by several experts (Katzmarzyk et al., 2007). However, the use of BMI has been criticized by some as it does not provide information about fat distribution in the body, which has specifically been linked to morbidity and mortality risks (Janssen et al., 2012).

Identification of overweight and obesity is more difficult in children and adolescents compared to adults, as normal growth and maturation during these developmental periods makes static cut-off points inappropriate with these populations (Himes, 2009). Moreover, age is an imperfect proxy for developmental stage, particularly during puberty when body composition changes rapidly (and differentially for boys and girls) (Must & Anderson, 2006). Three main classification strategies have been developed to address this challenge. The Centers for Disease Control and Prevention in the Unites States advocate for a distributional approach to BMI based on population growth curves, with age- and sex-normed percentiles to classify weight status. Using this approach, children and adolescents at or above the 85^{th} percentile for their age and sex would be considered "overweight" and those at or above the 95^{th} percentile would be considered "obese" (CDC, 2022b). The second strategy was developed by the International Obesity Task Force, who extrapolated adult BMI cut-off values backward into childhood based on a large international sample of children and adolescents (T. J. Cole, 2000; T. J. Cole & Lobstein, 2012). This yielded age- and sex-specific cut-off values for weight status that map onto identified health risks in adulthood (Katzmarzyk et al., 2007; Visscher et al., 2009). Finally, the World Health Organization (WHO) developed growth curves based on combined data from the National Center for Health Statistics and a large multicentre study conducted in six countries with pre-school aged children (De Onis, 2007; WHO Multicentre Growth Reference Study Group, 2006). This

system defines overweight as being one standard deviation above the median of this WHO reference growth standard, and obesity as two standard deviations above it (Llorca-Colomer et al., 2022). Prevalence rates of both overweight and obesity tend to be higher based on the WHO classification system (Llorca-Colomer et al., 2022); the other approaches yield similar thresholds when classifying overweight, but those for obesity differ based on age, with International Obesity Task Force cut-offs being generally higher (Katzmarzyk et al., 2007).

Prevalence of Childhood Obesity

In 1975, just under 1% of children and adolescents aged 5 to 19 years were considered to have obesity; in 2016, this figure rose to 6-8% – or 124 million young people (World Health Organization, 2021). This is projected to increase to 206 million by 2025 (Lobstein & Brinsden, 2019). These patterns are not restricted to Western countries, with 42 countries predicted to have over one million children with obesity in 2030 (*World Obesity Atlas 2022*, n.d.). Among Canadian children the prevalence of overweight and obesity is high with an estimated 13.1% of young people experiencing obesity. Although some estimates suggest rates have remained relatively stable for over a decade (D. P. Rao et al., 2016), rates of severe obesity are growing (Jebeile et al., 2022).

Etiology

Over one hundred years of research on the causes of obesity have revealed a complex interplay of genetic, metabolic, biologic, physical and behavioural variables that dictate whether a person will accumulate enough excess weight to be classified as having overweight or obesity (Wilborn et al., 2005). While genetics play an important role, with heritability of BMI estimated between 40-50% in adults (Bouchard, 2021), it does not account for the increasing trends in childhood obesity. The rapid increase in prevalence of overweight in parallel with relative

genetic profile stability suggests that environmental risk factors, such as availability and accessibility of healthy foods, parental modelling and feeding practices, consumption of ultra-processed and nutrient-poor food items, screen time, reduced activity levels, and peer influences are likely to account for the majority of cases of overweight and obesity (Pérusse et al., 2022; Sahoo et al., 2015; Williams et al., 2015).

Most biological scientific research and clinical treatment of obesity is predicated on the "energy balance model" to explain overweight – specifically, that when the number of calories consumed exceeds the number of calories that are expended, the excess energy is stored in the body in the form of fat accumulation (Ludwig et al., 2021; Wilborn et al., 2005; World Health Organization, 2021). Critics suggest that this merely describes the condition and does not provide an explanation for its occurrence (Ludwig et al., 2021). This likely represents an oversimplification of a complex process (Visscher et al., 2009) and potentially frames a physiological condition into a behavioural disorder (Taubes, 2021), the treatment for which is engaging in behaviours (such as caloric restriction) that alone may provide limited chance of sustained success and lead to unintended psychological consequences including the perpetuation of weight stigma and shame (Bacon & Aphramor, 2011).

Trajectory and Associated Health Outcomes

Adolescence, which typically refers to the period between 12 and 18 years of age, has been identified as a critical period for the development of overweight and obesity (Alberga et al., 2012; Daniels, 2005). This developmental stage is associated with marked changes in insulin sensitivity, hormone levels, muscle mass, fat distribution, height and activity levels, all of which may contribute to changes in adiposity (Alberga et al., 2012; D. P. Rao et al., 2016). Body composition changes in particular differ by sex, such that boys often experience a reduction in

body fat while females experience an increase (Daniels, 2005). Evidence suggests that obesity emerging during childhood and adolescence is associated with persistence of obesity later in life (Alberga et al., 2012; Daniels, 2005). Children with obesity are up to 80% more likely to experience obesity as adults than their normal weight peers (Daniels, 2005). Chronic obesity has been associated with a myriad of health difficulties in adulthood, including (but not limited to) cardiovascular disease, coronary heart disease, hypertension, type II diabetes mellitus, gallbladder disease, osteoarthritis, sleep disorders and several cancers (Kopelman et al., 2010; Uzogara, 2017; Wilborn et al., 2005). Adverse outcomes are not restricted to adults, with pediatric obesity contributing to the increasingly early development of conditions such as hypertension and cardiovascular disease, dyslipidemia, type 2 diabetes mellitus, obstructive sleep apnea and polycystic ovary syndrome (Daniels, 2005; Kelsey et al., 2014).

Psychosocial Outcomes

Beyond these impairments in physical health, the impact of obesity on mental health outcomes is wide-ranging. Early studies revealing that weight-based stigma begins as young as kindergarten (replication by Latner & Stunkard, 2003; original study by Richardson et al., 1961) contributed to a common hypothesis that children and youth with excess weight experience elevated levels of psychological distress (e.g., Liem et al., 2008; McElroy et al., 2004; Wardle & Cooke, 2005). Indeed, early onset obesity has been linked to increased risk of body dissatisfaction, bullying, stigma and discrimination, difficulties with peer relationships, low self-esteem, anxiety, depression, disordered eating and unhealthy weight-control behaviours, reduced quality of life, and even suicidal ideation (Chu et al., 2019; De La Haye et al., 2017; Kalarchian & Marcus, 2012; Puhl & Latner, 2007; Sagar & Gupta, 2018; Vander Wal & Mitchell, 2011). Among these, the most widely studied psychological outcome is depression.

Depression in Childhood and Adolescence

Definition and Assessment

"Depression" commonly refers to unipolar depressive disorder, though other associated disorders (e.g., dysthymia, mood dysregulation disorder, premenstrual dysphoric disorder, etc.) fall under the same diagnostic umbrella characterized by low mood and somatic and cognitive changes which negatively impact a person's ability to function. The diagnostic criteria for major depressive disorder outlined by the (DSM-5; American Psychiatric Association 2013) are virtually the same for adults and for children/adolescents, with two noted variations. Diagnosis of a major depressive episode requires at least five of nine of the following symptoms be present most of the day nearly every day during a two-week period and represent a change from previous functioning: depressed mood, diminished interest or pleasure, significant weight loss/weight gain or decrease/increase in appetite, insomnia or hypersomnia, psychomotor retardation or agitation, fatigue or loss of energy, feelings of worthlessness or excessive guilt, diminished ability to concentrate, and/or recurrent thoughts of death or suicidal ideation (American Psychiatric Association 2013). In children and youth, mood may manifest as irritable rather than depressed, and failure to meet expected weight gain may be present rather than significant weight loss. The other prominent classification system, the International Classification of Diseases (World Health Organization, 2004) defines a depressive episode similarly, with an added symptom of loss of confidence or self-esteem. Both systems require that symptoms cause clinically significant impairment in functioning.

Major depressive disorder accompanied by "atypical features" may be particularly relevant in the context of obesity (Liem et al., 2008; Reeves et al., 2008). This subtype of depression is characterized by mood reactivity accompanied by at least two of the following:

hypersomnia, increased appetite, weight gain, motor retardation or decreased energy, leaden paralysis and sensitivity to interpersonal rejection (American Psychiatric Association 2013). In particular, symptoms such as increased appetite, hypersomnia and decreased energy may have a direct influence on energy intake and expenditure and may contribute to weight gain and obesity (Lasserre et al., 2014). Researchers have found that biological processes common in both depression and obesity, including changes in hypothalamic-pituitary-adrenal axis functioning and pro-inflammatory cytokines, appear to be more closely related to atypical presentations of depression (Lasselin, 2020; Lyndon et al., 2017) compared to melancholic depression. However, the atypical specifier is considered controversial, particularly among children and youth (Paing et al., 2008), as some of the designated features may instead represent compensatory strategies for regulating emotion rather than defining characteristics (Łojko & Rybakowski, 2017; Lyndon et al., 2017). Depression with atypical features has been associated with early symptom onset, anxiety, and some indicators of bipolar disorder, and has shown differential treatment response to certain pharmacological interventions (Thase, 2009).

Major depression is ideally diagnosed using diagnostic interviews in the context of a thorough clinical assessment, including consideration of the degree of impairment. However, a great deal of research conducted with population-based samples of children and youth define cases of "depression" as elevated scores on a continuous measure of depressive symptoms, such as the Children's Depression Inventory (Kovacs, 1985) or the Center for Epidemiological Studies Depression Scale (Radloff, 1977), that exceed established cut-off values. These may be likely to identify both cases of major depressive disorder and sub-threshold levels of depression. Most studies reviewed in this synthesis relied on self-report questionnaires rather than diagnostic

interviews and reported scores as continuous data. As such, the findings presented herein refer to the presence of depressive symptoms rather than clinical diagnoses of depressive disorders.

Prevalence

The prevalence of major depression tends to be low (i.e., less than 2% for children under 13 years) among young children (Spoelma et al., 2023) and increases sharply with the onset of puberty (Thapar et al., 2012), with a continued linear rise throughout adulthood (U. Rao & Chen, 2009). The typical age of onset for depression in young people is approximately 13 years for major depressive disorder and 11 years for dysthymia (Lewinsohn et al., 2003). In Canada, youth aged 15 to 24 years have the highest rates of depression of any age group (Findlay, 2017). The 6-month prevalence of major depressive disorder among Canadian youth has been estimated at 7.5% in 12- to 17-year-olds, with markedly different rates for males (5.1%) and females (10.2%) (Georgiades et al., 2019). The lifetime prevalence of adolescents aged 15 to 18 was 7.6% (4.3% for males, 11.3% for females) (A. H. Cheung & Dewa, 2006). These rates have been climbing at an alarming rate: a nationally representative sample of adolescents aged 12- to 17- years in the U.S. found rates of past-year major depressive episodes increased significantly from 8.1% in 2009 to 15.8% in 2019 (Daly, 2022). This increase was observed across gender, ethnicity, and income groups (Daly, 2022).

A clear sex difference in the prevalence of depression has been consistently observed, where females are two to three times more likely to report depression than their male counterparts (Morken et al., 2023; Salk et al., 2017; Sun et al., 2023). This reliably emerges after pubertal onset, prior to which little to no sex differences are found (U. Rao & Chen, 2009; Salk et al., 2016). This gender gap has been shown to be consistent across different countries and measures of depression, and across both clinical diagnoses and sub-clinical depressive symptoms

(Shorey et al., 2022). Some evidence suggests this gender gap may be widening; for example, Daly (2022) found that the difference in rates of reported depression between males and females grew substantially from 6.4 to 14.8 percentage points over ten years.

Trajectory and Sequelae

Major depression in adolescence has been shown to persist and predict recurrence into adulthood (Lewinsohn et al., 2003). It has also been associated with maladaptive behaviours including substance abuse, smoking, and academic and psychosocial problems (Afifi et al., 2005; Clayborne et al., 2019; U. Rao & Chen, 2009). Suicidal ideation, intent and attempts are also prevalent among adolescents with depression (Hammen et al., 2014). Sub-threshold levels of depression (i.e. symptom levels that do not meet threshold criteria for determining diagnoses) during adolescence have been associated with negative outcomes almost equally as poor as those for major depressive disorder, including psychiatric morbidity, negative quality of life and significant health service use (Hammen et al., 2014; Wesselhoeft et al., 2013). They are also likely to be a precursor to the development of major depressive disorder in adulthood (Wesselhoeft et al., 2013).

Association Between Obesity and Depression

Obesity and mental health difficulties share important areas of overlap. Both tend to be particularly emergent during adolescence, a timing linked to hormonal, body composition, and social identity changes (Hazen et al., 2008) that may play a role in the onset of both conditions. The increasing incidence of both during the teen years is raising public health concerns, to the point that some consider them to be ‘sibling epidemics’ (Sharma, 2012a, p. 3). Obesity and depression share some similarities in their possible clinical presentation, including disrupted sleep patterns, increased sedentary behaviours, changes in appetite and food intake, and negative

self-image (Reeves et al., 2008). Evidence suggests that they may share underlying biological pathways, including dysregulated stress response systems, increased inflammatory responses, appetite signalling neurochemicals, and changes in hypothalamic-pituitary-adrenal axis functioning (Fulton et al., 2022; Hryhorczuk et al., 2013; Wilson et al., 2023).

While both conditions have serious consequences for functioning and quality of life (Griffiths et al., 2010), comorbidity of obesity and depression is associated with a more severe course of illness and poorer outcomes (McElroy, 2015). Depressive symptoms may include decreased energy, decreased motivation, low self-efficacy, changes in appetite, difficulty concentrating, and feelings of helplessness or worthlessness (American Psychiatric Association 2013), all of which may interfere with engaging in health promoting behaviours and weight management treatment (Fulkerson et al., 2004). For example, Zeller and colleagues (M. Zeller et al., 2004) found that adolescents with obesity who withdrew from weight management treatment (55% of those initially enrolled) reported significantly greater depressive symptomatology than program completers, independent of degree of overweight. Self-reported depressive symptomatology has also negatively predicted the number of treatment sessions attended by children and adolescents enrolled at a family-based weight management clinic (Jensen et al., 2012). Patients presenting for weight management who have comorbid depression also tend to experience less weight loss and have poorer adherence rates than those without depression (Faulconbridge et al., 2018). A better understanding how the association between obesity and depression, particularly among young people, could therefore lead to more effective assessment and treatment outcomes.

Comorbidity

The last twenty years have spawned a body of epidemiologic evidence seeking to establish whether children and adolescents with overweight/obesity are in fact more likely to experience depression than their lower weight counterparts. This evidence has been summarized in recently published systematic reviews. Sutaria and colleagues (2019) conducted a meta-analysis of 22 community-based observational studies of the association between weight status and depressive symptoms in this population. They found that 10.4% of children with obesity had depression, and those with obesity were 1.32 times more likely to exhibit depression than children within the "normal" weight range. Studies employing longitudinal designs ($k = 10$) yielded somewhat higher odds of future depression than concurrent depression assessed in cross-sectional studies. Further subgroup analyses revealed a particularly elevated risk for females compared to males; no effect for overweight was identified (Sutaria et al., 2019). These estimates echoed findings by Quek, Tam, Zhang, and Ho (2017), who systematically reviewed 18 studies and found an increased risk of both depression (OR = 1.34, 95% CI: 1.1 – 1.64, $p = 0.005$) and severe depressive symptoms (SMD = 0.23, 95% CI: 0.025 – 0.44, $p = 0.028$) among children and adolescents with obesity, and particularly among females. Mannan, Mamun, Doi, and Clavarino (2016) examined the bidirectional link between weight status and depression in prospective, community-based studies. Pooled estimates from six studies indicated those with obesity had a 40% risk of experiencing depression, which the authors estimated yielded an absolute risk that obesity at baseline added 1% likelihood of the development of subsequent depression. The authors acknowledged this may represent an underestimation resulting from a small number of studies and short follow-up periods that may not have allowed sufficient time for depression and/or obesity to manifest (Mannan et al., 2016). Another systematic review with stringent

methodological inclusion criteria also concluded that the evidence of a weak association was confirmed by available evidence, which suggested this relationship is consistently stronger for females and is possibly age-dependent (Mühlig et al., 2016b). Finally, in contrast, Moradi, Mozaffari, Askari, and Azadbakht (2022) analyzed data from 28 studies found no significant overall association between overweight or obesity and risk of depression. However, subgroup analyses indicated that overweight predicted depression among girls, while obesity predicted depression in samples from the U.S., lower quality studies, and both males and females (Moradi et al., 2022).

Taken together, this evidence consistently indicates that children and adolescents with obesity, but not necessarily overweight, are more likely to experience depressive symptoms than their lower weight counterparts. The average magnitude of this effect varies across studies and appears to be consistently greater for females compared to males. Critically, there was some overlap in included studies among these reviews (Moradi et al., 2022; Quek et al., 2017; W.-W. Rao et al., 2019; Sutaria et al., 2019) – though not as much as would be expected given the similarity in search strategies and inclusion criteria – so their results cannot be considered mutually exclusive.

These estimates were all derived from exclusively population-based samples. Individuals who seek voluntary weight loss treatment are de facto more likely to be distressed by their body size and/or associated conditions by virtue of their enrollment in treatment. Children and adolescent weight-based treatment seekers often report high levels of depressive symptoms, with estimates typically ranging from 20-50% (Dreber et al., 2015; Galler et al., 2024; Herget et al., 2014; Lindberg et al., 2020; Sheinbein et al., 2019). Rates of psychiatric comorbidity in this population have been shown to be significantly greater than normal weight controls (Dreber et

al., 2017; Gruszka et al., 2020; Lindberg et al., 2020) and non-clinical samples of youth with obesity (Britz et al., 2000; Dreber et al., 2017; Van Vlierberghe et al., 2009). It is possible that observed differences in depression may be related to characteristics of treatment seekers rather than the severity of obesity independent of the treatment setting. To mitigate this potential source of bias, the current review focused exclusively on non-clinical samples.

While these reviews focused on obesity as a predictor of depression, there is some evidence to suggest that depression may also contribute to the development of obesity. This direction of effect, however, has been investigated less frequently in children and adolescents and the evidence supporting its significance is less consistent (Kanellopoulou et al., 2022). A review by Mannan and colleagues (2016) compared the association in both directions and concluded that adolescents with depression had a 70% increased risk of future obesity, while those with obesity had a 40% chance of future depression. In contrast, Mühlig and colleagues (2016b) identified six longitudinal studies which found no evidence of a predictive effect of depression on obesity, and three finding an effect only for females. One important shortcoming of this literature is that some included studies failed to account for baseline weight status, which may have posed a serious threat to the validity of results (Faith et al., 2002). Some authors have posited this influence is related to features associated with “atypical” presentations of depression (e.g., disordered sleep, reduced physical activity, and changes in appetite or “emotional eating”), which may act as mechanisms through which weight gain may occur (Lasserre et al., 2014). This may also be a cyclical phenomenon, wherein excess weight contributes to the development of depression, the symptoms of which and associated coping strategies may contribute to further weight gain over time (Korczak et al., 2013). While the focus of this review will be exclusively on obesity as a predictor of depression in children and adolescents, future research, based on

longitudinal data collected over sufficiently long time periods to properly assess the development of overweight and obesity while controlling for baseline weight, could be directed towards further exploration of this reciprocal link.

Moderators of the Relationship Between Obesity and Depression

This body of research has established that a link exists between obesity and depression, though the magnitude of this association has varied across meta-analytic estimates. This variability may reflect the heterogeneity of this population, which is often treated in scientific research as monolithic. Individuals with overweight and obesity may be more different than similar, and their susceptibility to depression may be moderated by other sociodemographic characteristics (de Wit et al., 2010; Hampl et al., 2023a; Quek et al., 2017). Moderation occurs when the size, sign, or strength of the relationship between two variables depends on the level of a third variable, or moderator (Preacher et al., 2007). Evidence of moderation is apparent from results identifying a significant obesity-depression relationship only for individuals in particular groups. Several variables may play a moderating role; three key characteristics are considered below.

Gender/Sex. The most frequently investigated potential moderator of the obesity-depression link in children and adolescents is gender. Females with overweight or obesity are consistently shown to be at increased risk for experiencing depressive symptoms compared to their normal weight female counterparts (Mühlig et al., 2016b; Quek et al., 2017; Sutaria et al., 2019). It should be noted, however, that increased risk among females does not necessarily indicate a lack of risk among males (e.g., Mustillo et al., 2003), and that some studies investigating the obesity-depression link in adolescents have done so with female-only samples (e.g., Stice et al., 2000; Stice & Bearman, 2001). A prevailing hypothesis for this observed

difference, which reliably manifests during adolescence, is that thinness is a socially and culturally defined ideal for females more so than for males, and the departure from this ideal that typically occurs for girls during puberty may result in psychological distress (Hermes & Keel, 2003; Russell-Mayhew et al., 2012; Stice & Bearman, 2001). This is supported by findings of a linear relationship between BMI and body dissatisfaction in females and a parabolic relationship in males (Austin et al., 2009), for whom the ideal is lean muscularity (Russell-Mayhew et al., 2012).

While many studies purport to investigate the role of 'gender differences' in the obesity-depression link, most do not clearly differentiate gender from sex differences (Haynes 2019). Very few describe whether alternative responses to traditional male/female identities were presented to participants. Fewer still report data separately for non-traditional gender identities or speculate how gender non-conformity may fit into proposed theoretical models, despite evidence that transgender and non-binary youth may experience increased risk for body image and eating disturbances (Heiden-Rootes et al., 2023). This is problematic, as guidelines for evaluating gender in scientific research caution against using simple proxies to measure identity (such as asking an individual to check a box describing their gender) and assuming information about them that was not directly measured (Lowik et al., 2022). Thus, it is arguable that 'sex' may more accurately describe the data presented in the current literature. However, it is conceivable that both biological sex and gender influence the relationship between obesity and depression. For example, sex differences may be apparent in levels of inflammatory markers associated with both conditions (Elgellaie et al., 2023), while internalization of social beauty standards is more likely to be influenced by one's gender identity (Boswell & White, 2015). Given that the latter is likely more relevant to the proposed psychological, social, and behavioural pathways under

investigation in this review, ‘gender’ is henceforth intentionally employed to avoid conflating these two related yet distinct constructs.

Developmental Stage. The risk of depression among young people with obesity may also differ based on their developmental stage. Puberty, which describes the developmental period during characterized by maturation of secondary sex characteristics, hormonal changes, and physiological changes in body composition, typically occurs between ages 8 and 14 years (Conley & Rudolph, 2009), though its onset in males is typically approximately 2 years later in males compared to females (Hoyt et al., 2020). Puberty is associated with physical growth and weight gain which typically moves females away from traditional social ideals for physical appearance (via increased body fat and widening of the hips), while simultaneously moving males towards social ideals (via increased lean muscle mass and broadening of the shoulders) (Loomba-Albrecht & Styne, 2009). This shift coincides with a period in development that places increased importance on physical appearance as part of the self-concept (Conley & Rudolph, 2009), and the role of peers (Pearce et al., 2002). It follows then that the onset of puberty has been associated with poorer body image and disordered eating, particularly for females (Rodgers et al., 2014). As obesity has been linked to early pubertal onset (Hoyt et al., 2020), young people who experience early pubertal onset may be more likely to exhibit depressive symptoms than their same-aged peers, for whom weight gain may be more normative (Needham & Crosnoe, 2005; Stice & Bearman, 2001).

Culture. Culture plays an often implicit yet pivotal role in many psychosocial models of the obesity-depression link. The shape and size of a human body are themselves without relative value; it is only within the context of social messages (implicit or explicit) that an individual comes to understand their weight as “good” or “bad” (Thomas et al., 2014). The nature of these

messages is highly influenced by the social and cultural groups to which that individual belongs. Cultural ideals impose social value on what it means to live in an obese body; they both influence how an individual with obesity is treated by others and how they themselves experience obesity (Wardle & Cooke, 2005). Membership in cultural groups with different perspectives on body weight and shape is expected to moderate the relationship between obesity and mental health outcomes, such that individuals with obesity who are also members of a group which highly values thinness are more likely to experience negative mental health outcomes than those in groups more accepting of larger bodies. Group membership can be distinguished based on any number of constructs, including social class, socioeconomic status, level of acculturation, and most commonly, ethnicity.

Ethnicity refers to "shared cultural characteristics such as language, ancestry, practices, and beliefs" (APA, 2019). Groups may differ in the degree to which they value and prioritize physical appearance, the physical attributes viewed as attractive or desirable (e.g., thinness, curves), and even the prevalence of different body types among members. For example, Western cultural values – which generally refer to European American/white culture – place high value on physical appearance and thinness particularly for women, present this ideal as normative and within individual control, and associate it with social acceptance and success (Warren et al., 2005). In contrast, research has shown that Black women tend to experience lower levels of body dissatisfaction, less internalization of social beauty standards, and view larger bodies more favourably than White women (see Awad et al., 2015). Ethnicity has been proposed to influence the effect of obesity on depression through cultural acceptance of thin ideals, though ethnicity as a moderator has not received significant empirical attention (Faith et al., 2011; Wardle & Cooke, 2005). Some studies have identified a significant moderating effect of ethnicity, where increased

risk for depression has been found for White/European participants (particularly females) but not for Black/African American and to a lesser extent, Hispanic participants (e.g., Anderson et al., 2011; BeLue et al., 2009; Erickson et al., 2000; Gavin et al., 2010). Comparatively less evidence is available for other ethnicities, although there is evidence for an obesity-depression link among adolescents in China (W.-W. Rao et al., 2019). The effects of ethnicity and culture more broadly have been under-investigated in this literature considering the possible magnitude of its influence.

Mechanisms of Action

Evidence presented thus far suggests that young people with obesity are at increased risk for depression. The magnitude of this risk varies based on several putative moderating characteristics, including one's gender, developmental stage, and culture. While these moderators serve to identify *when* and *for whom* excess weight may predict depression, the question of *how* this occurs remains unclear. The mechanisms through which this risk is conferred are less understood.

Biological and Genetic Processes

Several biological processes are common to both obesity and depression and may partially explain their association. Alteration of the inflammatory system, including increased levels of C-reactive protein and pro-inflammatory cytokines, is one example (Fulton et al., 2022). Individuals with obesity frequently experience chronic inflammation and the accumulation of white adipose tissue, which is associated with increased cytokine production (Slavich & Irwin, 2014). Cytokines have been found to disrupt and downregulate serotonin production, and their presence is sometimes used as a biomarker for depression (Lopresti & Drummond, 2013; Poletti et al., 2024) Abdominal adiposity in particular has been associated

with dysregulation of the hypothalamic-pituitary-adrenal axis, leading to altered levels of hormones including cortisol, leptin, insulin and adiponectin – all of which have been implicated in both satiety signalling and the control of emotion (Hryhorczuk et al., 2013). For example, chronic up-regulation of the hypothalamic-pituitary-adrenal axis leads to hypercortisolism, which has been associated with "melancholic" features of depression, whereas down-regulation has been associated with "atypical" features including increased sleep and appetite (Hryhorczuk et al., 2013; Reeves et al., 2008). Finally, genetic polymorphisms involved in both may account for some of the variance between obesity and depression, likely through encoding for glucocorticoids and receptors for leptin or dopamine (Blasco et al., 2020). However, results of a twin study found that only approximately 12% of the genetic component of depression is shared with obesity, suggesting this accounts for a modest proportion of their association (Afari et al., 2010). Support for such biological mechanisms continues to develop and is bolstered by a finding that "metabolically healthy" individuals with obesity may not be at increased risk for depression (Hamer et al., 2012). Nonetheless, it is unlikely that these pathways account for all the co-variation between obesity and depression, particularly in children and adolescents who may not have had sufficient exposure to obesity to have developed these sometimes-chronic biological dysregulations. Instead, it is likely that these mechanisms are complex and interact with other environmental, psychological and social factors (Lopresti & Drummond, 2013).

Psychosocial and Behavioural Processes

In an early call to investigate the causal pathways between obesity and depression, Stunkard, Faith and Allison (2003) posited that factors such as eating, physical activity, appearance-related teasing, and stress likely act as mediators through which excess weight contributes to the development of depressive symptoms. Since then, a substantial body of

evidence has been gathered investigating the role of these and other putative mediators, such as disordered eating (Lewis-Smith et al., 2020), health concerns (Markowitz et al., 2008), bullying (D.-R. Chen et al., 2023), sleep (Konjarski et al., 2018), stress (Pervanidou & Chrousos, 2011), and body image (Voelker et al., 2015). These research findings are disparate, with many assessing variables as correlates of either obesity or depression separately. Studies often lack theoretical justification for the choice of mediators or employ design or statistical methods that do not allow the investigation of intermediary mechanisms (e.g., assuming a causal relationship based on cross-sectional data, without controlling for possible confound). Those studies that do examine the process often examine single mediators, in different populations, using different measures. This heterogeneity presents a significant challenge to interpreting patterns and pinpointing areas for effective clinical intervention.

Preiss, Brennan and Clarke (2013) attempted to summarize this evidence by systematically reviewing the literature for any proposed predictors, correlates, mediators and moderators of the relationship between obesity and depression in adult-only samples. Their broad review of 46 studies found that severity of obesity, body image, socioeconomic status, psychological factors, physical health, interpersonal effectiveness, binge eating and the experience of stigma were “consistently” associated with the relationship between obesity and depression, while support was “equivocal” for variables such as sex, ethnicity, and physical activity (Preiss et al., 2013). Although a thorough synopsis of available evidence at the time, some limitations should be considered. First, they employed exclusive use of qualitative vote counting (i.e., counting the number of statistically significant findings) to evaluate ‘consistency’, without a required minimum number of findings per outcome or any risk of bias assessment for included studies. This is likely to exacerbate the effects of reporting bias and overlook findings

from underpowered studies (McKenzie & Brennan, 2023), particularly when the number of studies investigating a given variable is low. The scope of the review was also intentionally broad, exploratory, and atheoretical. While thorough, results could not differentiate between mediators, correlates, and other related variables. This also resulted in high heterogeneity of methods, populations, measures, and statistical analyses among included studies, limiting the conclusions that could be drawn about the relative importance of each variable. Finally, the authors also explicitly excluded studies of participants younger than 18 years from their review, arguing that that variables influencing the relationship between obesity and depression in children and adolescents may be qualitatively different than those of relevance to adult populations.

Russell-Mayhew, McVey, Bardick, and Ireland (2012) reviewed literature combining obesity with mental health indicators and proposed a psychosocial model of obesity based on their findings. The model linked the experience of childhood obesity with psychosocial factors (including anxiety/depression, self-esteem, body dissatisfaction, eating disorder symptoms, and emotional problems), and identified the role of two mediating variables: weight-based stigmatization/teasing, and concern about weight and shape. Their model offered a unique contribution in that it also incorporated the role of wellness factors, including quality of life and resiliency, which are often overlooked by an evidence-base focused on pathology rather than protective factors or positive outcomes. However, several known correlates of obesity that may impact depression were intentionally omitted from the review, representing a gap in knowledge about their influence. These factors include culture/ethnicity, behavioural variables like sleep, and social or contextual influences like media or family (Russell-Mayhew et al., 2012). The relationships between model constructs were not entirely specified; for example, it was unclear

how or whether the psychosocial variables were temporally related to each other or the weight of their importance in the process. The authors explained that the existing evidence offered support for the role of the individual constructs in the model but was insufficient to estimate the magnitude of their effects or clarify the pathways between them and called for future research to employ the use of causal modelling techniques to address this gap (Russell-Mayhew et al., 2012). Thus, the picture of how these are linked and where best to intervene in this process to improve outcomes, is incomplete.

Taking a more theoretical approach, Sikorski, Luppa, Luck, and Riedel-Heller (2015) presented a model of internalized stigma developed from the field of sexual minority research and extended it to another minority group subject to social stigma – individuals with obesity. The *minority stress paradigm* (Meyer, 2003), intended to explain the higher prevalence of mental health issues among minority groups, posits that membership in these groups exposes individuals to chronic social stressors (in the form of stigma, social exclusion, devaluation, etc.). These "distal" stressors activate two types of "proximal" psychological processes: general processes linked to psychological outcomes among the general population (e.g., coping strategies, social support, emotion regulation), and group-specific processes, which represent internal processes (e.g. subjective appraisal, internalized stigma) that are unique to or more prevalent among minority group members (Hatzenbuehler, 2009).

The authors reviewed scientific evidence to evaluate the effect of these processes on psychopathology among individuals with obesity (Sikorski et al., 2015). Body dissatisfaction emerged as a consistent group-specific process among children and youth in the small number of studies included. The most frequently investigated general risk factor was self-esteem, followed by coping and social support, though variability based on ethnicity/culture across studies was

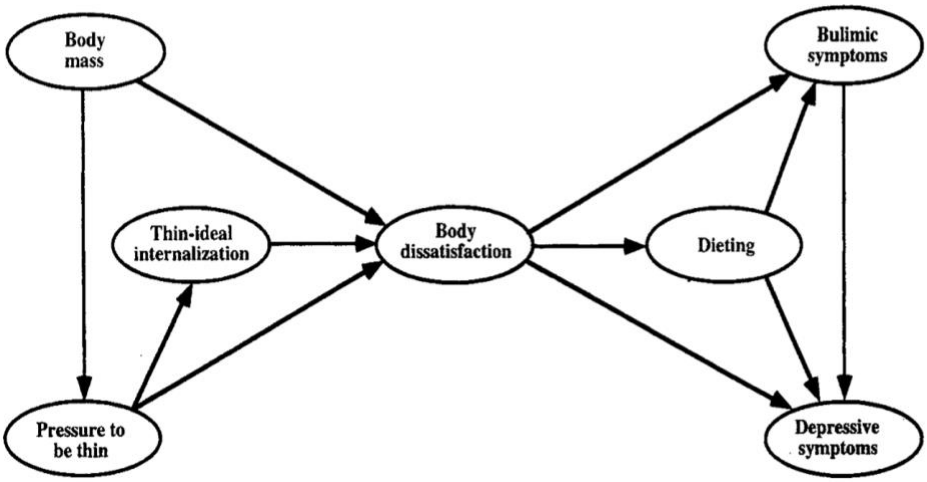
identified. Further, studies specifically investigating mediation found a positive association between weight-based stigma and psychopathology. Although the model seeks to explain the mediating effect of internalized weight bias, the authors only identified two studies that specifically investigated this construct, both in adult samples (Durso et al., 2012; Hilbert et al., 2014). Notably this study employed a broad definition of psychopathological outcomes not limited to depression. Search terms were constrained to constructs specified in the model, so relevant mediators not included therein (for example, dieting) would not have been captured and their effects could not be compared to the model. Further, the relatively small number of included studies precluded confirmation of the model pathways, though results suggest group-specific processes play an important role. These reviews have made important contributions in consolidating a breadth of primary evidence available at the time. The models they depict are helpful at representing a complex process, however the evidence in support of their components was limited. In the case of the study by Russell-Mayhew and colleagues (2012), some potentially important contextual variables were omitted from the review. Both Preiss (Preiss et al., 2013) and Russell-Mayhew (Russell-Mayhew et al., 2012) lacked a theoretical basis for their findings, which is crucial in the investigation of causal mechanisms (Frazier et al., 2004). While the premise investigated by Sikorski and colleagues (2015) was based on established theory, 'group specific' processes were not clearly operationalized, so it was not evident which variables would be included under this term. An alternative model that addresses these shortcomings is considered in this review.

The *gender additive model* (GAM) (Stice & Bearman, 2001) is a theoretical model of depression that may be particularly applicable to the context of obesity. It seeks to explain why the prevalence of depression reliably increases for females beginning in adolescence, and points

to the combination of body image concerns and eating behaviours as a culprit for this gender difference. Based on the dual pathway theory of bulimia nervosa (Stice, 1994; Stice & Agras, 1998), the GAM posits that females are likely to experience social pressure to be thin, which contributes to internalization of a thin ideal and subsequent body dissatisfaction. The emotional discomfort associated with these cognitions leads young women to engage in unhealthy compensatory behaviours and eating practices – even insofar as to exhibit symptoms of eating disorders such as bulimia – which over time contribute to the development of depressive symptoms. This pathway is represented in Figure 1.

Figure 1

Gender Additive Model of Depression (Stice & Bearman, 2001)



The premise of this model is that hypothesized pathways apply more strongly to females than to males, particularly during adolescence. (Notably absent is any consideration of gender identity or non-conformity; thus, in the current context this might more accurately be conceptualized as a 'sex-based additive model'.) While this process is expected to apply to all

females undergoing developmentally normative weight gain associated with healthy development, those who stray most from the culturally ascribed thin ideal are at greatest risk for negative outcomes (Stice & Bearman, 2001). Teens with overweight and obesity, it follows, would be most likely to experience depression based on this model. This review posits that GAM mechanisms explain, at least in part, the higher rates of depression among those with overweight or obesity. People in larger bodies experience social pressure to be thin from multiple sources (Puhl et al., 2017) and have demonstrated high rates of both body dissatisfaction (Weinberger et al., 2016) and disordered eating (Chaves et al., 2023). This review endeavours to understand whether these associations contribute to the development of depression. The strength of the associations is expected to vary based on gender, pubertal timing, and culture.

Initial investigations of the validity of the GAM demonstrated support for model constructs in predicting both clinical depression (Stice et al., 2000) and depressive symptoms (Stice & Bearman, 2001) in small, female-only samples. Neither of these found direct effects of BMI on depression and concluded that perception of one's body may be more influential than actual body size. Later, Bearman & Stice (2008) replicated their findings in a mixed-sex sample, though only body dissatisfaction remained significant once established risk factors common to both males and females (negative affectivity and lack of social support) were included in the analysis. Vaughan & Halpern's (2010) prospective examination of a simplified version of the model found significant longitudinal associations for all but one model pathway. However, findings did not support the premise that gender moderates these effects; instead, they found that increased risk among girls was because they were more likely to experience weight concerns and dieting, not that they are more vulnerable to depression in the face of these concerns (Vaughan &

Halpern, 2010). Santos, Richards and Bleckley (2007) obtained similar results, with significant pathways among model constructs for both males and females.

The GAM is particularly applicable as it proposes specific, testable variables and clearly explains the hypothesized links between them. Model constructs such as internalization of a thin ideal have been linked to both obesity (Hilbert et al., 2014) and depression (Klaczynski et al., 2004), however whether this acts as an intermediary between the two has yet to be established. The GAM is based on theory (Stice, 1994; Stice & Agras, 1998), from the field of eating disorders, specifically bulimia nervosa, an area that has shown notable overlap with obesity (Rancourt & McCullough, 2015). Findings from this review will be framed in the context of the GAM, such that the mediating effects of variables included in the GAM will be compared to those not in the model.

Finally, putative mediators were classified based on one of the most widely researched and implemented treatment approaches for depression in adolescents (Korczak et al., 2023; Oud et al., 2019; Viswanathan et al., 2020): cognitive behavioural therapy (CBT). The framework underlying this approach incorporates both cognitive and behavioural theories, and emphasizes the role of a person's thoughts, beliefs, assumptions, and interpretations in influencing their emotions, behaviours, and ultimately increasing the risk for psychological distress (Beck, 1979). Applied in the context of obesity, it is the meaning ascribed to having overweight, rather than the presence of overweight itself, which negatively impacts mood and confers increased risk of developing depressive symptoms over time. This meaning is formed by a person's thoughts about weight – for example, whether they identify as someone with overweight or obesity, the value they place on body shape and size, degree to which they believe body weight is under their personal control, and their assumptions about the social implications of having overweight. The

behavioural principle of this framework dictates that a person's behaviour impacts both thoughts and emotions and is central to maintaining or changing maladaptive patterns (Westbrook et al., 2011). For example, individuals who view weight as under their personal control may engage in dieting behaviours to change their weight; the success or failure of these efforts would play a strong role in reinforcing or contradicting these beliefs and the emotions they elicit. Finally, cognitions and behaviours are highly influenced by contextual factors, which may activate underlying schemas and assumptions (Dozois & Beck, 2008). Because many beliefs about obesity are informed by sociocultural influences, the term 'social' mediators will herein be used to describe these influences. For example, many youth with obesity are victims of peer and family pressure to lose weight (Helfert & Warschburger, 2013), which over time can contribute to internalized weight bias (Fields et al., 2021) and negative outcomes like low self-esteem and psychological distress (Puhl & Lessard, 2020).

Obesity may represent an example of a particular vulnerability to experiencing depression in young people, which can be framed based on a CBT conceptualization. Several researchers in the area have speculated that the risk of depression is conferred through a combination of cognitive, behavioural, and social factors (Markowitz et al., 2008; Napolitano & Foster, 2008; Sharma, 2012b), though these may have different strengths of effect. This review seeks to compare the magnitude of effect of cognitive, social, and behavioural mediators to understand where assessment and treatment efforts should be focused.

Investigating Mechanisms: Statistical Mediation Analysis

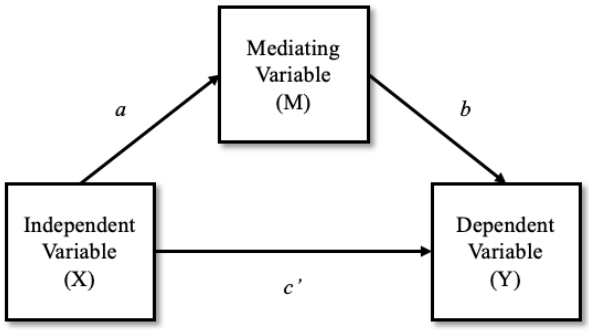
Each of the aforementioned models describes proposed causal mechanisms through which weight status exerts an influence on depression. There are several methodological and statistical approaches through which to evaluate intermediary mechanisms; many researchers in

this area have advocated for the use of mediation analysis (Friedman & Brownell, 1995). The current review seeks to examine evidence that employs this methodology to clarify the role of psychosocial and behavioural mediators of the relationship between weight status and depression. First, an introduction to mediation analysis is presented:

A mediator is a variable through which an exposure exerts an effect on an outcome (Hayes, 2013). At its core, mediation analysis refers to statistical techniques used to test theoretically causal pathways between an exposure, mediator, and outcome, and serves to answer the question of "why" or "how" two variables are related (Frazier et al., 2004). A graphical representation of a basic single mediator model is presented in Figure 2.

Figure 2

Basic Single Mediator Model[1]



In this model, X represents the independent variable, M represents the mediator, and Y represents the dependent variable; while *a* denotes the relation of X to M, *b* the relation of M to Y adjusted for X, and *c*′ the relation of X to Y adjusted for M (referred to as the *direct effect*). The product of paths *a* and *b* describes the *indirect effect* of X on Y through mediator M, while *c*

[1] (see Fairchild & McDaniel, 2017; MacKinnon et al., 2007)

describes the *total effect* of X on Y (without accounting for the effect of M). These relationships can be described by the following equation:

$$c = c' + ab \quad (1)$$

Thus, the *total effect* (c) of variable X on variable Y can be broken down into the sum of the *direct effect* (c') of X on Y and the *indirect effect* (ab) of X on Y through M (Preacher & Hayes, 2008). Mediation is said to occur when the magnitude of the total effect is significantly reduced with the inclusion of the mediator into the model (Hayes, 2009). Several methods have been developed through which to test the significance of this mediation effect, each with specific benefits and drawbacks. Typically, mediation analysis requires that the model parameters be estimated using either ordinary least squares regression (with relationships expressed as regression coefficients), or maximum likelihood approaches such as structural equation modelling (with relationships expressed as path coefficients) (Frazier et al., 2004; Hayes, 2009).

One of the earliest methods, the "causal steps approach" credited to Baron and Kenny (1986), stipulates that mediation can only be established if the following criteria are met: a) X significantly accounts for variability in M, b) X significantly accounts for variability in Y, c) M significantly accounts for variability in Y when controlling for X, and d) the effect of X on Y is significantly reduced when M is included in the model ($c > c'$) (Baron & Kenny, 1986; Preacher & Hayes, 2008). Although this is the most widely used approach in psychological research, several limitations have been identified which call into question its continued utility. A major concern is its low power to detect true effects in the absence of a large effect size and/or sample size, leading to high Type II errors (Fairchild & McDaniel, 2017; MacKinnon et al., 2002). This is related to the requirement that a significant total effect of X on Y be identified for mediation to

have occurred; several have argued that this is unnecessary and may overshadow possible suppression effects (Frazier et al., 2004; MacKinnon et al., 2002). Hayes (2009) explains that it also crucially does not provide any quantifiable estimate of the mediation effect, which is merely inferred based on the stated criteria. Despite these flaws, its simplicity and past popularity influence its continued widespread use.

The second type of analysis is known as the "difference in coefficients" test, which essentially requires demonstration of a significant difference in the parameter estimate of X on Y after adjustment for the effects of the mediator. It can be represented as $c - c'$, the significance of which can be tested by dividing this difference by its corresponding normal theory standard error (Fairchild & McDaniel, 2017). This method is advantageous compared to the causal steps approach in that it provides a testable estimate of the magnitude of the mediated effect and has greater statistical power with comparably low Type I error rates (MacKinnon et al., 2002). However, as it provides a composite estimate, it does not allow for the examination of individual mediator effects in multi-mediator models and cannot necessarily distinguish between true mediation and confounding effects (Fairchild & McDaniel, 2017).

The final class of mediation analyses is known as the "product of coefficients" approach, wherein the indirect effect is calculated by multiplying paths *a* and *b* in the general model (see Figure 2). This offers the flexibility of examining individual mediator effects in complex models (Fairchild & McDaniel, 2017). Several methods exist for testing the significance of this indirect effect, which involve variations of dividing the *ab* estimate by its standard error and comparing the result to a normal distribution (MacKinnon et al., 2002). The most widely used version is the Sobel test, which is often used in practice as an adjunct to the causal steps approach to mitigate the lack of a statistical test of the estimate of the mediated effect (Hayes, 2009). Unfortunately,

like the causal steps approach, the Sobel test can also be underpowered when used with small samples, because it assumes a normal sampling distribution of *ab* (Fairchild & McDaniel, 2017). Some authors (Fairchild & McDaniel, 2017; Hayes, 2009) advocate that instead, significance testing of the product of coefficients approach should make use of newer techniques such as bootstrapping (which makes no assumptions regarding the shape and sampling distribution of the indirect effect and does not require an estimate of standard error), which offers more power and thusly lower Type II error rates than other approaches.

Additionally, studies investigating complex, multiple mediator models often make use of causal modelling approaches such as structural equation modelling or path analysis. In these cases, some authors evaluate the significance of the mediated effects in the full model by comparing model fit with and without inclusion of the direct effect of the predictor on the outcome. Mediation is said to occur if the addition of the direct effect to the model does not improve overall fit (Frazier et al., 2004).

Rationale for the Current Study

Current evidence indicates that young people with excess weight, particularly females, are more likely to experience depression than their peers with normal weight (Quek et al., 2017; Sutaria et al., 2019). This is concerning, as both have been shown to persist into adulthood when they manifest during childhood or adolescence (Johnson et al., 2018; Ward et al., 2017). Comorbidity of obesity and depression is associated with a more severe course of illness and poorer outcomes than either condition alone (McElroy, 2015). Individuals experiencing both obesity and depression are likely to be treated for each condition separately, as the presence of clinical depression is often an exclusion criterion for pediatric obesity treatment studies (Faulconbridge et al., 2018). The presence of depression may also limit participation in health

promoting behaviours and weight-related treatment (Jensen et al., 2012). To improve health outcomes for this vulnerable population, scarce healthcare resources must be directed towards interrupting the process through which overweight and obesity contributes to depression. At present, this process remains poorly understood.

The seminal work of Stunkard, Faith and Allison (2003) strongly advocated for the investigation of moderation and mediation effects to clarify the causal pathways between obesity and depression. Other prominent researchers in the area (Markowitz et al., 2008; Preiss et al., 2013; Russell-Mayhew et al., 2012) have echoed these calls to employ mediation, causal modelling, and path analysis to better understand this phenomenon. Since then, a range of possible mediators have been investigated in disparate primary studies, but the magnitude and relative importance of their effects remains unclear. Thus, an updated synthesis of these findings is warranted to translate this knowledge into useable guidance for decision-makers and inform treatment strategies.

The current systematic review seeks to add to the knowledge base by synthesizing and critically evaluating the evidence investigating psychological, social and behavioural variables that mediate the relationship between overweight/obesity and depression in children and adolescents. The population of interest was exclusively child and adolescent samples, as the pathways relating weight to depressive symptoms during this vulnerable time are likely to be different from those in adults (Napolitano & Foster, 2008). Only studies that employ the use of formal mediation analysis or causal modelling were included, to narrow the focus to intermediary mechanisms. Previous summaries of available evidence have exclusively employed qualitative vote counting, often without evaluating potential bias inherent in this method. This gap was addressed by conducting both quantitative and qualitative syntheses, which allowed a

comparison of the relative magnitude of effect across different mediators independent of the statistical significance of individual effects. Further, structured tools were used to assess the risk of bias in individual reports, and a detailed framework based on established methodology was used to evaluate the strength of synthesis findings for each outcome.

Mediation findings were framed in the context of a promising theoretical model - the GAM (Stice & Bearman, 2001), and its validity as an explanatory model critically appraised. This was accomplished by conducting subgroup analysis to compare the mediating effects of GAM variables to those not included in the model. Evidence is also considered both at the level of individual mediators as well as more broadly by mediator class – specifically by grouping constructs into cognitive, social, and behavioural mechanisms based on a cognitive behavioural framework. This serves to facilitate comparisons of effects across models that may incorporate different, yet related, variables (see Markowitz et al., 2008; Napolitano & Foster, 2008; Russell-Mayhew et al., 2012), and point to target areas for prevention, treatment, and research development.

Objective

The primary objective of this systematic review and meta-analysis was to investigate the role of psychological, social, and behavioural mediators of the relationship between weight status and depression that are specifically relevant to children and adolescents. This was accomplished by identifying, evaluating, and synthesizing data from published studies to address the following research goals:

1. To examine the average overall effect of psychological, social, and behavioural mediators on the relationship between weight status and depression in children and adolescents.

2. To determine whether individual characteristics (gender, developmental stage, and culture) moderate the mediated effects of psychosocial and behavioural variables on the relationship between weight status and depression.
3. To evaluate the validity of GAM variables as mediators of the relationship between weight status and depression in young people.
4. To investigate the relative strength of the indirect effects of different mediators on the relationship between weight status and depression in children and adolescents.

Methods

The methodology for this systematic review followed the guidance from the Cochrane Handbook for Systematic Reviews of Interventions (Higgins et al., 2022), Conducting Systematic Reviews and Meta-Analyses of Observational Studies of Etiology (COSMOS-E) (Dekkers et al., 2019), and reporting follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Checklist (Page et al., 2021). The protocol for the review was posted to Open Science Framework on June 19, 2023. A copy of this protocol and an explanation for any deviations from it are documented in Appendix A and B, respectively.

Research Goals, Questions, and Hypotheses

This review is structured to address four main research goals. Several specific research questions and hypotheses were developed, based on previous research, through which to achieve these goals. These questions and hypotheses are outlined in Table 1.

Table 1

Research Goals, Research Questions, & Review Hypotheses

Research Goal	Research Questions (Outcomes)	Hypotheses
To examine the average overall effect of psychological, social, and behavioural mediators on the relationship between weight status and depression in children and adolescents.	1a. Do psychosocial and behavioural variables mediate the relationship between weight status and depression in children and adolescents?	1a. Psychosocial and behavioural variables included in this review will significantly mediate the relationship between weight status and depression.
	1b. What is the average magnitude of the indirect effect of all psychosocial and behavioural mediators on the relationship between weight status and depression in this population?	1b. (no stated hypothesis)
	1c. How much of the total relationship between weight status and depression can be explained by the indirect effect of psychosocial and behavioural mediators?	1c. (no stated hypothesis)
To determine whether individual characteristics (gender, developmental stage, and culture) moderate the mediated effects of psychosocial and behavioural variables on the relationship between weight status and depression.	2a. (*Gender*) Is the magnitude of the average indirect effect significantly different between males and females?	2a. The average overall indirect and total effects will be significantly higher for females compared to males.
	2b. (*Developmental stage*) Is the magnitude of the average indirect effect significantly different between youth who experience early-onset puberty and those who experience normative or late-onset puberty?	2b. The average overall indirect effect will be significantly stronger for youth who experience early-onset puberty compared to those who experience normative or late-onset puberty[a].
	2c. (*Culture*) Is the magnitude of the average indirect effect significantly different for members of cultural groups that endorse a thin ideal compared to	2c. The average overall indirect effect will be stronger for youth who endorse membership in cultural groups that endorse a thin ideal,

	groups that do not endorse a thin ideal?	compared to groups that do not endorse a thin ideal.
To evaluate the validity of GAM variables as mediators of the relationship between weight status and depression in young people.	3a. Is the average indirect effect of all mediators moderated by inclusion in the GAM (variables included in the GAM/non-GAM variables)?	3a. Inclusion in the GAM will moderate the average overall indirect effect of all mediators.
	3b. Do variables included in the GAM significantly mediate the relationship between weight status and depression in children and adolescents? What is the magnitude of the average indirect effect of these variables?	3b. GAM variables will significantly mediate the relationship between weight status and depression (i.e., the average indirect effect for mediators included in the GAM will be significant). (No stated hypothesis regarding the magnitude of this effect.)[c]
	3c. Is the average indirect effect of GAM variables stronger than the average indirect effect of non-GAM variables?	3c. GAM variables will have a significantly stronger mediating effect than variables not included in the GAM
	3d. Is the average indirect effect of GAM variables different between males and females?	3d. The average mediating effect of GAM variables will be stronger for females than for males.
	3e. Is the average indirect effect of GAM variables significantly different between youth who experience early-onset puberty and those who experience normative or late-onset puberty?	3e. The average mediating effect of GAM variables will be stronger for those experiencing early onset puberty compared to those experiencing normative or late pubertal onset.
	3f. Is the average indirect effect of GAM variables significantly different between members of cultural groups that endorse a thin ideal compared to members of cultural groups that do not endorse a thin ideal?	3f. The average mediating effect of GAM variables will be higher for members of cultural groups that endorse a thin ideal compared to

		those that do not endorse a thin ideal.
To investigate the relative strength of the indirect effects of different mediators on the relationship between weight status and depression in children and adolescents.	4a. Which class of mediator (i.e., cognitive, social, behavioural) has the strongest average indirect effect on the relationship between weight status and depression in children and adolescents? Are these average indirect effects significantly different from one another? 4b. What specific individual psychological, social, and/or behavioural variables significantly mediate the relationship between weight status and depression in children and adolescents?	4a. (no stated hypothesis) 4b. (no stated hypothesis)

[a] If age is used as a proxy for development, it is hypothesized that mediation would be stronger for those in early adolescence compared to those in mid- or late adolescence.
[b] Components of the gender additive model of depression (GAM; Stice & Bearman, 2001) are: internalization of a thin ideal, pressure to be thin, body dissatisfaction, dieting, and eating disorder symptomatology

Eligibility Criteria

Studies were considered eligible for inclusion in the review if they met the following pre-specified inclusion/exclusion criteria:

Study Population

Age. Study participants must have been school-aged children and adolescents between the ages of five and 18 years, or up to 22 years for studies conducting a longitudinal follow-up of participants initially assessed prior to age 18. The current research standard is that individuals above 18 years are considered to be adults. However, several longitudinal studies investigate the

relationship between obesity and depression initially during adolescence, with follow-up into early adulthood. Further, several organizations (e.g., Statistics Canada, 2022; UNESCO, n.d.; United Nations, n.d.; World Health Organization, n.d.) define 'youth' as individuals less than 24 years of age. It was deemed important to capture this data despite the age range falling outside the typical standard age for classifying adolescence. Therefore, only studies whose mandate included an investigation of children and adolescents, who investigated variables prior to 18 and who followed up intentionally after this age were included and extracted. Studies investigating a wider age range (for example, 12 to 65 years) which included the current population of interest were deemed eligible, but data was only extracted if child and adolescent data was presented separately from adult data.

Sample type. Clinical samples consisting of individuals seeking treatment for weight management were excluded, as this group is expected to exhibit higher levels of mental health difficulties that may not be representative of the general population (Fitzgibbon et al., 1993; M. H. Zeller et al., 2006). Special populations, such as samples comprised exclusively of individuals with pre-existing comorbid medical conditions or mental health difficulties, were also excluded.

Study Design and Report Characteristics

Original publications written in English examining primary or secondary data were deemed relevant for inclusion. Acceptable study designs included descriptive (i.e., case series) and observational (i.e., cross-sectional, longitudinal, case-control) designs. Systematic reviews, narrative reviews, editorial reviews, abstracts, clinical practice guidelines and grey literature were excluded, as were reports of case studies of single participants. Results of clinical trials, or the implementation of interventions aimed at addressing weight status and/or mental health outcomes were excluded. Reports describing only qualitative data were excluded.

Independent and Dependent Variables

Independent Variable: Weight Status. Included studies must have investigated body weight/size as the independent variable. Broad definitions of weight were considered acceptable, including continuous weight estimates, assessment of weight status categories (i.e., "normal" weight, "overweight", "obese") based on reference standards, or other estimates of body size. Any measurement protocols (i.e., objective measurement or self-report) and any reference standards for the classification of weight status were eligible for inclusion.

Dependent Variable: Depression. The outcome of interest in the included studies was the presence of depression. Relevant studies examined depression as a dependent variable within the mediation chain. This included studies investigating the presence of depressive symptoms, as well as those investigating clinical diagnoses. Any operational definition of depression (i.e., total scores on measures of depressive symptoms, exceeding clinical cut-off scores on self-report measures, interview-based assessment for the research study, clinical diagnoses), as assessed by any instrument, process, or protocol, was deemed relevant for inclusion.

Mediators. The primary aim of this review was to uncover potential mechanisms through which weight status contributes to depression in children and adolescents. To achieve this, a broad scope was adopted, wherein *any* psychological, social, or behavioural variable proposed to mediate the relationship between weight and depression was considered appropriate. Further, any measures or methods used to assess these variables was also deemed relevant for the purposes of study selection. Investigations of exclusively biological mediators, such as pro-inflammatory cytokines or elevated cortisol levels, were beyond the scope of the current study. Although one of the stated goals was to investigate the mediating role of variables included in the GAM,

inclusion was *not* limited to only these variables, so their effects could be compared against other possible mediators.

Analyses. As the intent of this review was to examine the *process* through which the experience of overweight contributes to the experience of depression in young people, only studies which specifically employed statistical mediation analysis, in which weight was assessed as the independent variable and depression the dependent variable, were included. Established mediation analyses include but are not limited to the causal steps approach (Baron & Kenny, 1986), the product of coefficients approach (a common example of which is known as the Sobel Test; (Sobel, 1982), the difference in coefficients approach (see MacKinnon et al., 2002), model fit (Holmbeck, 1997), and bootstrapping methods (Preacher & Hayes, 2004). Investigations of both single and multiple mediation models were considered relevant, although effects of all mediators were considered individually.

Information Sources

Initial searches were conducted on August 22, 2014, using the EbscoHOST interface: MEDLINE, CINAHL and PsycINFO. Searches were limited to articles published in English. As well, several PubMed subsets were searched to identify material not yet included in MEDLINE (Duffy et al., 2014). The MEDLINE search strategy was developed by a librarian experienced in systematic review searching, and peer reviewed by another librarian, using the PRESS standard (McGowan et al., 2010). The MEDLINE search was then adapted for the other database. An update was conducted December 17, 2020, to capture research published since the initial search. The MEDLINE and PsycINFO searches were translated to the Ovid interface, CINAHL was updated in the EbscoHost database. The PubMed search was not repeated as the newest material

from PubMed is present in Ovid MEDLINE. Some handsearching was also systematically done as reference lists of eligible studies were also examined

Search Strategy

The full search strategies are presented in Appendix C. Search terms included “obesity”, “overweight or overweight”, “body mass index or bmi”, “adiposity or waist circumference or waist ratio or skin fold”, "depression+", “depression or depressive”, “child*”, “adolescen*”.

Unit of Analysis

Bibliographic records identified through the systematic literature search represent single research ‘reports’, or publications. Sometimes, several individual reports may describe the same larger research study (Lefebvre et al., 2022), as may be the case with largescale population-based epidemiological studies. In systematic reviews and meta-analyses, it is crucial to ensure the independence of included effects, so the same data is not unintentionally counted multiple times, leading to imprecise and biased review conclusions (Borenstein, 2013). To protect against this risk of bias, each included report was examined, and those describing the same larger study were collated and a primary report was identified. Secondary reports were included, and their data extracted, but only data that was not reported elsewhere was included in quantitative synthesis. The term ‘report’ will henceforth be used in this review to ensure clarity and consistency.

Data Management

Records were initially downloaded to Reference Manager (Thompson Reuters) for duplicate removal and exported into Excel (Microsoft) for screening. The record was subsequently transferred into a web-based software platform, Covidence (Veritas Health Innovation), for screening and data extraction. Records were managed in Zotero (Corporation for

Digital Scholarship). Extracted data was then verified and exported into Microsoft Excel for sorting and coding. Finally, quantitative analyses were conducted in *R* (R Core Team, 2022) using *metafor,* an add-on package for conducting meta-analysis (Viechtbauer, 2010).

Selection Process

All bibliographic records were double coded by two independent reviewers using *a priori* established eligibility criteria (described above). Screening was conducted in two steps: initially by examining only the title and abstract, then by examining the full text document for those not dually excluded at the first stage. The choice to use blind, independent screeners was made to minimize the potential for selection bias (Wright et al., 2007) and maximize the reproducibility of screening decisions (Lefebvre et al., 2022). Disagreements were resolved by forced consensus, and, when necessary, by consultation with a third reviewer. Before screening began, protocols and eligibility criteria were pilot tested on a small sample (5%) of identified reports to ensure they served to accurately differentiate relevant from irrelevant reports and to confirm that they could be applied reliably by multiple reviewers. Items were re-worded, made more specific, and examples provided to the screening guidelines as necessary, and the process repeated until a percent agreement rate of 80% was achieved (McHugh, 2012).

Data collection process

Once screening was complete, data was extracted from all included reports using form templates created in Covidence (Veritas Health Innovation) systematic review software. A coding guide (see Appendix D) was created to provide instructions for each extraction item; this was used as a reference for both data extraction and verification of the data collected. The data extraction template and coding guide were pilot tested on four eligible reports to ensure all necessary data points were adequately captured. Next, relevant data from all eligible reports was

extracted by one reviewer and independently verified by another. Any data conversions or transformations required for inclusion in meta-analysis were further verified by an individual with expertise in statistical analysis. Discrepancies were resolved through discussion, and if necessary, additional consultation.

Data Extracted from Individual Studies

A list of variables extracted from individual studies is presented in Table 2. A detailed template and coding guide for all data extraction is presented in Appendix D.

Table 2

Data Extracted from Each Report

Item	Data Extracted from Each Report
Report Identifiers	Author names Year of publication Country of Origin
Study Design and Sample Characteristics	Type of design (cross-sectional/longitudinal) Length of follow-up (longitudinal designs only) Population (e.g., community, school-based) Sample size (and size of subgroups reported) Gender/sex distribution Ethnicity distribution of sample Age range Name of larger population-based study from which data was drawn (if applicable)
Independent Variable: Weight Status	Method(s) of weight measurement Objective assessment vs. self-report Operational definition of overweight/obesity (reference standards used)
Dependent Variable: Depression	Method of assessment (name of measure(s), method of administration) Operational definition of depression (symptom endorsement vs. clinical diagnosis vs. clinical cut-off scores, continuous vs. categorical)
Mediators: (primary outcome of interest)	Name of each mediator Measurement tool(s) Estimate of the indirect effect(s) (standardized regression coefficients for paths *a, b, a*b, c, c'*)[1] Estimate of the total effect (*c*)[2] Was the estimate of the indirect effect (or other mediation effect) tested for statistical significance?

	Type of statistical analysis used to assess magnitude/significance of mediation (causal steps, Sobel test, bootstrapping, difference of coefficients, model fit, proportion mediated, joint significance, other)
Moderators: (subgroup analysis)	*Gender*: Was moderation by gender investigated, and/or results presented separately for males/females/other genders? Results of moderation analysis and/or significance of mediated effect for males/females/other genders *Developmental Stage*: Was moderation by developmental stage (early onset puberty, normative pubertal onset, or late pubertal onset OR pre-, peri-, and post-pubertal onset) investigated, and/or were results presented separately by age or developmental stage? *Culture/Ethnicity*: Was moderation by culture/ethnicity investigated, and/or were results presented separately by cultural group/ethnicity membership? *Gender Additive Model*: Is mediator part of the GAM? (yes/no) *Mediator Class*: Mediator class (i.e., cognitive, social, behavioural)
Other Relevant Variables:	Name of confounder(s) or relevant covariate(s) assessed

[1]Standardized regression coefficients were extracted for each path in the basic mediation model (see Figure 2), and missing data was calculated based on the general mediation formula (1); see "Preparing Data for Synthesis" section below.
[2]The total effect refers to the estimate of the relationship between weight status and depression, without controlling for the effect of proposed mediator(s), path *c* in the basic mediation model.

Risk of Bias in Individual Reports

Assessing the risk of bias in observational studies is particularly challenging, as these include a variety of designs each with their own potential sources of bias (Sterne et al., 2022; Viswanathan et al., 2017). Sanderson and colleagues (2007) reviewed quality assessment tools designed for use with observational studies. While they identified over 86 tools, they concluded that no "gold standard" instrument exists that can be applied reliably across different designs, that little consensus on critical items has been achieved, and that most tools require adaptations to fit the needs of individual reviews. Many available tools were designed to assess study quality, and do not reflect the shift in the evidence synthesis literature towards more specific risk of bias assessment (i.e., internal validity, rather than imprecision or external validity) (Boutron et al., 2022). Further, no tool has been developed specifically to assess sources of potential bias among mediation findings, such as temporal order bias or use of inappropriate mediation methods (Vo & Vansteelandt, 2021).

Several possible critical appraisal tools were considered for use in the current review, including the Newcastle-Ottawa Scale (Wells et al., n.d.), the ROBINS-I (Sterne et al., 2016), and the National Heart, Lung, and Blood Institute Quality Assessment Tool (National Heart, Lung, and Blood Institute, 2019). Two complimentary measures from the Joanna Briggs Institute (JBI) suite of critical appraisal tools were ultimately selected: 1) the checklist for analytical cross-sectional studies (Moola et al., 2020) (Appendix E), and 2) the checklist for cohort studies (Moola et al., 2020) (Appendix F). These tools were designed to critically assess the methodological quality of research at the study level (Munn et al., 2020). One advantage of this suite is that each tool contains items specific to a particular study design (e.g., adequacy of length of follow-up for longitudinal analyses) while maintaining consistency of domains across

tools. In line with guidance from the Cochrane handbook (Boutron et al., 2022), the JBI instruments do not employ the use of an overall composite score for critical appraisal, but rather a qualitative rating based on consideration of each item assessed and the study as a whole. Signaling questions and instructions are provided for each item included in the checklists, as well as the overall appraisal rating, to operationalize each construct and increase inter-rater reliability.

This instrument was not designed specifically for the assessment of mediation studies and does not include items that evaluate quality or bias specific to this type of analysis. As such, amendments to the original checklists were made to adequately capture these specific threats to internal validity. Mediation analysis, at its core, seeks to clarify a theoretically causal pathway between the exposure, mediator(s), and outcome. As Frazier and colleagues (2004) explain, any degree of "causation" can only be inferred if three conditions are met: a) an association exists between the variables, b) this association is not "spurious", and c) the "cause precedes the effect in time" (Frazier et al., 2004, p. 127). While it is impossible to fully satisfy these conditions, particularly in nonexperimental designs, controlling for threats to each can increase confidence in conclusions regarding mediation effects without inferring true causation (Frazier et al., 2004). Amendments and additions to the original JBI tools were made specifically to evaluate these conditions in the context of mediation-based studies. For example, an item regarding temporal precedence was added to the checklist for cohort/longitudinal designs (see Appendix F), and the identification and management of confounders was given particular importance in assessing the overall risk of bias for a given study (Appendix E). The complete list of modifications made to the original checklists are outline in Appendix G.

Critical appraisal of each included report was conducted by two independent reviewers. The tools were reviewed in detail prior to assessment and any discrepancies in interpretation of

items and their relative importance were discussed. JBI instructions were supplemented with guidance from the ROBINS-I (Sterne et al., 2016) and Cochrane Handbook for Systematic Reviews of Interventions (Boutron et al., 2022) to aid with interpretation of items. The process was also piloted on a small sample of included studies (2 cross-sectional designs, 2 cohort/longitudinal designs) to ensure the tool was being used correctly and adequately capturing the sources of bias inherent to the included studies. Discrepancies were resolved by discussion and forced consensus. Given that the number of included studies was relatively small, and the variability in overall risk of bias ratings was also limited, analyses were not restricted to only those studies demonstrating a low risk of bias.

Synthesis Methods

This review aims to address four main research goals (Table 1). In service of this aim, two types of synthesis are presented for each goal: quantitative synthesis (commonly known as meta-analysis), and qualitative synthesis (commonly known as narrative synthesis). A description of each method is provided below.

Meta-Analysis (Quantitative Synthesis Methods)

The first goal was to examine the effects of psychosocial and behavioural mediators on the relationship between weight status and depression in children and adolescents. This was accomplished by conducting two random-effects meta-regressions to compute: a) the average overall indirect effect of all investigated mediators, and b) the average overall total effect of weight status and depressive symptoms from all eligible reports.

A random-effects model was selected because heterogeneity of methods, measures, and populations was expected between studies. This model assumes that actual variability (in addition to that conferred by chance or error) exists across estimates, and the aim of the analysis

is then to estimate the mean of the distribution of these true effects (Borenstein, 2013; Deeks et al., 2023). This mean is typically computed by weighing each study by the inverse of its variance, which is a combination of the within-study variance and the estimated variance between studies (Borenstein, 2013). Unfortunately, very few included reports provided study-specific variance or error estimates for the standardized regression coefficients of the indirect effect. After consultation with multiple statisticians (including the author of the *metafor* package), it was determined that there was not sufficient information reported (including the variance-covariance matrix of the regression model in the individual studies) to estimate the within-study variance. Thus, the weight of each effect included in meta-analysis was computed based only on the sample size of each report (Haslam et al., 2020; Nakagawa et al., 2023).

Following the initial meta-regressions, subgroup analyses were then performed to evaluate whether the following constructs moderated the overall average indirect and total effects: (i) gender (female/male) (*Research Goal 2*), (ii) inclusion in the GAM (included/not included) (*Research Goal 3*), and (iii) mediator class (cognitive/social/behavioural) (*Research Goal 4*). While subgroup analyses were initially planned for developmental stage (early-/normative-/late-onset puberty) and culture (identification with cultural group that places high value on thin ideal/does not highly value thin ideal), these were not possible due to an insufficient number of reported effects; see Results section for details. Differences between subgroups were detected using an omnibus test (i.e., a test of the null hypothesis that all subgroup effect sizes are equal) (Borenstein & Higgins, 2013; Harrer et al., 2021). A significant omnibus test indicated that the observed average effects differed significantly between subgroups.

Eligibility for Inclusion in Quantitative Synthesis. Effect estimates were eligible for inclusion in meta-analysis if the indirect effect (*ab*) was reported, or if sufficient data was reported from which to calculate *ab* and/or total effects (*c*) based on (1) (see "Preparing Data for Synthesis" section below). These effects were only included if presented as standardized regression coefficients, or if standardized regression coefficients could be calculated using (2) based on available data.

Several included reports examined models with more than one mediator, describing multiple indirect effects. In these cases, estimates for each mediator in a single study were provided by the same participants, and thus cannot be considered independent from one another. A central tenet of meta-analysis is the independence of effects; the inclusion of two effects from the same study yields imprecise summary effect estimates (by underestimating the error and overestimating precision) and assigns more weight to studies with multiple outcomes (Borenstein, 2013). Although methods exist from which to combine these estimates for use in meta-analysis (Borenstein, 2013), these methods require both the variance of each mediator and the correlation between them. As this information was unavailable for most reports, only one indirect effect estimate was selected per report for inclusion in meta-analysis. Effects of the remaining mediators were extracted and presented in complimentary qualitative synthesis. The following criteria were used to select the indirect effects to be included in meta-analysis when multiple effects were reported:

a) Mediators with the most complete data (i.e., data points for all outcomes of interest)
b) Estimates presented as standardized regression coefficients, or in a format that allowed conversion to standardized regression coefficients.

c) Subgroups of participants that were most comparable to other study samples (e.g., based on age range) to minimize heterogeneity.

d) Mediators that maximized equal representation across planned subgroups (i.e., females/males, cognitive/social/behavioural mediators, mediators included in the *gender additive model*) to enhance power and increase comparability across subgroups.

In cases where a study reported multiple outcomes for the *same* mediator, the following eligibility criteria were considered:

- Where estimates were presented separately for different measures of weight status (e.g., a study reported both BMI and waist circumference), only estimates using BMI were extracted. BMI was the most common metric for weight status across studies; its selection as the metric of interest was made to minimize heterogeneity and maximize comparability between studies.
- Where estimates were presented separately for different operational definitions of depression (e.g., both a total self-report measure score indicating the degree of depressive symptomatology and a categorical measure of depression based on a clinical cut-off score), both estimates were extracted for consideration in qualitative synthesis and for possible sensitivity analyses. However, given that two such estimates in the same study would violate the requirement of independence of effects in meta-analysis (Borenstein, 2013), only the continuous measure of depressive symptoms was selected for inclusion in meta-analysis to facilitate pooling of effects.

Effect Size Estimates. The main outcome of interest was the magnitude of the indirect effect (also known as the mediation effect) of weight status on depression through a putative

mediator. This was measured using the 'product of coefficients' approach, where the indirect effect is equal to the product of the path coefficients for the regression of the mediator on the independent variable (i.e., weight status) and the regression of the dependent variable on the mediator. This is represented by paths *a* and *b* in the basic mediation model (see Figure 2). Numerous techniques exist with which to evaluate the indirect effect; the product of coefficients approach was selected because it allows the effects of single mediators to be extracted from complex multi-mediator models, is calculable from both regression-based and SEM/path analyses and provides higher power than other common approaches (Fairchild & McDaniel, 2017; Preacher & Kelley, 2011).

No gold standard exists for communicating the magnitude of the indirect effect in mediation analysis. As such, two complimentary methods were selected for this review. First, the value of the indirect effect was categorized based on guidance from Kenny (Kenny, 2024), which suggests that values proposed by Shrout and Bolger (2002) should be squared because the indirect effect represents the product of two effects. Thus, an effect of .01 was considered small, .09 was considered medium, and .25 considered large. Second, the 'mediation ratio' or 'proportion mediated' (P_M) is reported, which represents the ratio of indirect to total effects (Fairchild & McDaniel, 2017; Preacher & Kelley, 2011). This is one of the most commonly reported measures of effect size in mediation analysis and allows the effects of single mediators to be examined within multiple mediator pathways (Fairchild et al., 2009). This estimate should be interpreted cautiously, however, as it does not reflect a true proportion (i.e., its value can be greater than one or negative) and is much more stable with large sample sizes (Fairchild et al., 2009; Preacher & Kelley, 2011). As such, the proportion mediated is only reported for the

average overall indirect effects and not for subgroup analyses, as its utility and accuracy are diminished as the number of available estimates decreases.

The standardized regression coefficient (β) was selected as the measure of effect size for both indirect and total effects. Most studies employed the use of regression-based analyses or path analysis/SEM methods, reporting standardized and/or unstandardized coefficients for the relationships being investigated. Given that individual studies examined different mediators, assessed by a variety of different measures, the values of unstandardized estimates would not be comparable across studies and thus have limited value in synthesis. Standardizing coefficients entails converting unstandardized estimates to a common unit of measurement (in this case standard deviations), making the estimates comparable regardless of the scale used. The standardized regression coefficient has been supported as an acceptable unit of effect size in mediation (Preacher & Kelley, 2011) and in meta-analysis (Nieminen, 2022).

Preparing Data for Synthesis. The product of coefficients approach entails an estimate of the indirect effect *ab* (see Figure 2). Some studies specifically reported this effect as *ab,* while others reported estimates separately for paths *a, b, c* and *c',* in which case the product of coefficients *a* and *b* was calculated using the general mediation formula (MacKinnon et al., 2007):

$$c = c' + ab \quad (1)$$

Where:

c: total effect of the independent variable on the dependent variable (without controlling for the mediator)

c': direct effect of the independent variable on the dependent variable (controlling for the mediator)

a: path coefficient of the mediator regressed on the independent variable

b: path coefficient of the dependent variable regressed on the mediator

The majority of included studies reported the standardized regression coefficient, which was the effect size selected for the current quantitative analyses. Those that reported only the unstandardized regression coefficients were converted into standardized coefficients using the following formula (Bring, 1994):

$$\beta = B^*[SDx/SDy] \quad (2)$$
$$SD = SE\sqrt{n}$$

Where:

β: the standardized regression coefficient

B: the unstandardized regression coefficient

SDx: the standard deviation of the independent variable (exposure)

SDy: the standard deviation of the dependent variable (outcome)

SE: standard error

n: sample size

Methods to Explore Heterogeneity. One goal of meta-analysis is to determine the consistency of effects across studies. In random-effects meta-analysis, the difference in observed effects across reports is assumed to be the result of two factors: true differences in effects between reports and random error (Borenstein, 2013; Higgins, 2003). Different statistical tools exist with which to parse these sources of variability and evaluate the degree of heterogeneity between effects. The traditional measures of heterogeneity (such as *Q* statistics and I^2) require within-study variance, which were not available in the current dataset. Thus, following a newer meta-analysis approach (Haslam et al., 2020; Nakagawa et al., 2023), heterogeneity was assessed by examining the dispersion of confidence intervals across included effect estimates, as greater heterogeneity yields a wider ranging confidence interval. Visual inspection of forest plots also provided an approximation of consistency of observed effects. A high degree of heterogeneity was expected in both pooled indirect and total effects. Subgroup analyses were planned a priori to address research goals two, three, and four (see "Meta-Analysis" section above); these analyses also served to examine possible causes of heterogeneity of the overall average indirect and total effects. These were investigated using a combination of study-level variables and within-study contrasts (PRISMA guidelines; (Page et al., 2021), as different independent effects from the same study were sometimes included in multiple subgroups (e.g., a study reporting effect estimates separately for males and females would be represented in both subgroups for gender). All subgroups were determined a priori based on research objectives, previous research, and the theoretical framework outlined in the GAM.

Assessment of Reporting Bias. Reporting bias presents a risk to the validity of review findings because systematically missing data may differ from that that which is available for evidence synthesis (Deeks et al., 2023). This can occur when the selective publication or

reporting of research findings occurs based on the magnitude or significance of effects (Berkman et al., 2013). Methods for properly evaluating reporting bias in observational studies, such as those included in this review, are limited (Berkman et al., 2013). For the current review, a funnel plot of all indirect effects included in quantitative synthesis was selected to provide an estimate of publication bias. As with the meta-analyses, because within-study variance (i.e., standard errors of individual effects) was not reported, indirect effects were plotted against reported sample size for included reports. Symmetry of this funnel plot was examined to evaluate the probable impact of publication bias among included studies.

Qualitative Synthesis Methods

Qualitative synthesis of the evidence was also conducted to address each research goal. This fulfilled two purposes. First, it allowed the examination of available evidence in cases where quantitative synthesis was not possible or appropriate (for example, due to an insufficient number of data points, data reported in a format that did not allow conversion to appropriate units for meta-analysis, etc.). Second, quantitative synthesis is necessarily more restrictive, as it requires that all included effects be independent from one another. Thus, when a study reported effects for two different, yet possibly correlated, variables from the same sample, only one was eligible for inclusion in meta-analysis. This data omitted from meta-analysis can still provide useful information provided it is considered in appropriate context. The complimentary qualitative synthesis included all estimates of the significance of mediated effects, to thoroughly extract and summarize as much evidence as possible to answer the stated research questions. (Both the quantitative and qualitative syntheses are considered when presenting the findings: see "Rating the Strength of Available Evidence" section below.)

The method through which results were combined is referred to as vote counting based on statistical significance. Studies reporting a statistically significant mediation effect were considered as evidence that a particular construct acts as a mechanism through which weight status contributes to the development of depression. Non-significant results were considered as insufficient evidence of effect (rather than as evidence that no effect exists). This is critically important, as a notable limitation of this technique is that it may underestimate clinically meaningful effects when results from underpowered individual studies that fail to demonstrate a significant effect are considered as evidence of no effect (McKenzie & Brennan, 2023).

Mediation analyses present a challenge to synthesizing evidence, as some methods recommended by gold standard guidelines (Borenstein, 2013; McKenzie & Brennan, 2023) may be inappropriate. For example, vote counting based on direction of effect would not yield usable results, because any absolute difference (i.e., non-zero results in either direction) between the total and direct effects could be considered evidence of potential mediation, which would likely *overestimate* the role of several variables. Combining p-values would be equally limited in utility. Many included studies did not report an estimate of the indirect effect *ab* and its specific p-value; those that did often opted instead to describe conventional levels of significance (i.e., $p<0.05$, or simply "non-significant"). Combining these estimates would therefore be based on both an incomplete dataset and overly conservative estimates (i.e., assuming the lowest threshold of $p=0.05$) and would likely also result in Type II errors. As such, despite the aforementioned caveat, vote counting based on statistical significance (presented in concert with quantitative findings) was selected as the method for qualitative synthesis.

Eligibility for Inclusion in Qualitative Synthesis. The outcome of interest in qualitative synthesis is the significance of mediated effects. Although some studies reported the magnitude

of the indirect effect of a given mediator on the relationship between weight status and depression, not all assessed the statistical significance of the magnitude of this effect. Only those that assessed and reported the results of significance testing were eligible for inclusion in qualitative synthesis. Any method of significance testing, including but not limited to the commonly used Sobel test, the causal steps approach, and non-parametric bootstrapping, was considered relevant.

Rating the Strength of Available Evidence

A systematic review involves the synthesis and critical appraisal of available evidence in the service of answering specific research questions (Dekkers et al., 2019). Critical appraisal of a body of evidence involves applying pre-specified criteria to rate the authors' confidence that review findings represent true effects, which may be considered when making recommendations based on review findings (Kolaski et al., 2023). Several tools exist which provide authors with clear, systematic, and transparent guidelines for evaluating the strength of evidence for outcomes specified in the review (Page et al., 2021). The gold standard framework for evaluating the strength of evidence is the Grades of Recommendation, Assessment, Development and Evaluation (GRADE) system (Balshem et al., 2011; Schünemann et al., 2019). However, because it was originally designed to evaluate evidence based on randomized controlled trials, evidence derived from observational studies is necessarily relegated to a rating of "low" using this system. This is problematic when faced with research questions for which observational research represents the highest and most appropriate level of evidence available (Yousefifard & Shafiee, 2023). Given the fact that this review focuses exclusively on observational research, an adapted version of the "Evidence-Based Practice Centers Framework for Grading the Strength of Evidence" framework created by the Agency for Healthcare Research and Quality (EPC-AHRQ;

Berkman et al., 2013) was adopted to evaluate the strength of evidence synthesized in this review. This tool is based largely on the GRADE approach, while providing specific guidance regarding the evaluation of observational evidence. The strength of the evidence for each prespecified outcome is determined by considering two factors: a) the confidence in the estimate of effect, and b) the level of deficiencies in the body of evidence. Deficiencies are evaluated based on five required domains: limitations, directness, consistency, precision, and reporting bias. This tool was adapted for the purposes of this review to include instructions for rating each domain based on criteria specific to mediation-based evidence. Further, as per guidance in the framework, 'reporting bias was not assessed for each outcome, and instead is explored separately for the entire body of evidence. The adapted measure, including detailed definitions and instructions for coding each item, is included in Appendix H. The body of evidence for each research question/outcome was summarized and critically appraised by the principal investigator using this framework. Results are presented in-text for each specified outcome.

Results

Review results are presented in two parts: a) general findings, including a description of the selection process, characteristics of individual reports, and risk of bias assessment, and b) synthesis findings, including results of quantitative syntheses, qualitative syntheses, and a rating of the strength of the evidence for each research goal.

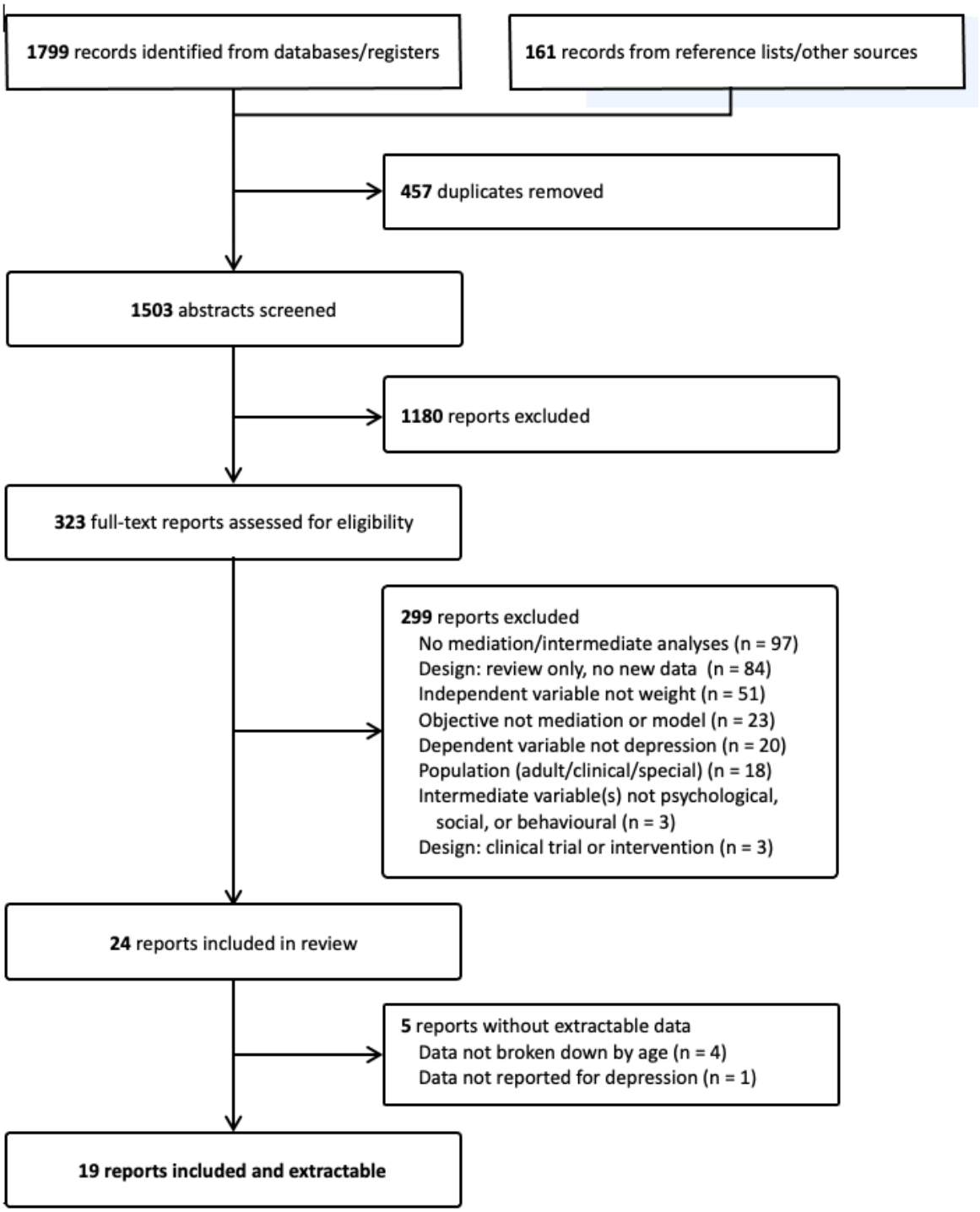
General Findings

Selection of Reports: Search Results and Screening

In total, 1799 records were identified through the database search and imported into a Reference Manager database, where duplicate references were removed, resulting in 1414 records for screening. A further 161 records were nominated for consideration by the reviewers based on reference lists of included studies and other sources. Thus, a total of 1503 abstracts were screened from which 323 full-text documents were then retrieved and screened. This process, depicted in Figure 3, identified 24 reports that satisfied all inclusion criteria. Of these 24 reports, four (Dimitriadis et al., 2016; Hilbert et al., 2014; Jeffers et al., 2013; Stevens et al., 2017) described samples comprised of both school-aged and adult participants but did not present data separately for participants under 18 years. One additional report (Shin & Shin, 2008) described performing mediation analyses but did not specifically report results of these analyses using depression as an outcome. Authors were contacted to request useable data, however only one author provided a response (Stevens et al., 2017), indicating that the requested data was not available. As data pertinent to the review criteria were not extractable, these five reports were excluded from all syntheses. Data was ultimately extracted and synthesized from a total of 19 reports.

Figure 3

PRISMA Diagram Reflecting the Selection Process for Including Reports*



*Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement (Page et al., 2020)

Sample Characteristics

A summary of characteristics of included reports is provided in Table 3. Many studies were conducted in the United States (8 reports), with others originating in Canada (2), Taiwan (2), Australia, Brazil, China, India, Ireland, the Netherlands, and South Korea. Participants' ethnicity was described in only eight reports (Ge et al., 2001; Mond et al., 2011; Needham & Crosnoe, 2005; Santos et al., 2007; Stice & Bearman, 2001; J. K. Thompson et al., 1995; Vaughan & Halpern, 2010; Xie et al., 2010), all of which were conducted in the United States. Sample sizes varied widely from 78 to 18,795, with a median of 859 participants. Participants' age ranged from seven to 22 years, with the median age 14 years and the modal age 12 years. As clinical populations were explicitly excluded from the review, samples were primarily drawn from schools, while the remainder were from larger community-based studies (Allen et al., 2006; Gomes et al., 2019; Pryor et al., 2016).

Table 3

Characteristics of Included Reports

First Author (Year)	n (% female)	Country	Design (length of follow-up)	Age	Weight Status Measure (Objective vs Subjective)	Depression Measure (Symptoms vs Diagnosis)	Mediator(s)	Mediator Measure(s)
Allen (2006)	207 (56%)	Australia	Cross	7-13 y	BMI (objective)	CDI-SF (symptoms)	Body Dissatisfaction ("weight and shape concern")	Child Eating Disorder Examination
Bang (2012)	455 (51%)	South Korea	Cross	Grade 5-6 (10-12 y)	BMI (objective)	CDI (symptoms)	(Parental) Teasing	Perception of Teasing Scale (Korean)
Chaiton (2009)	2294 (50.9%)	Canada	Cross	13 & 16 y	BMI, Skinfold Thickness (objective)	Psychological Distress Scale (French) (symptoms)	Pressure to be Thin	3 items: others dieting, negative weight comments, weight loss encouragement
							Body Dissatisfaction	Stunkard Figure Rating Scale + 1 item "trying to lose weight
Deepthi (2014)	78 (49%)	India	Cross	12-17 y	BMI (NR)	Birleşen Depression Self-Rating Scale for Children (NR)	Binge Eating	Binge Eating Scale
Ge (2001)	3633 (51.3%)	USA	Long (1 year)	Wave 1: 12-14 y Wave II: 13-15 y	BMI (objective)	CES-D (modified) (symptoms)	Weight Perception	1 item "how do you think of yourself in terms of weight?"
Gomes (2019)	2977 (NR)	Brazil	Long (4 years)	11, 15, 18-22 y @ follow-up	BMI, waist circumference, dual-energy X-	MINI version 5.0	Physical Activity	IPAQ long version
							Diet Quality	Revised Diet Quality Index

First Author (Year)	n (% female)	Country	Design (length of follow-up)	Age	Weight Status Measure (Objective vs Subjective)	Depression Measure (Symptoms vs Diagnosis)	Mediator(s)	Mediator Measure(s)
					ray absorptiometry (objective)			
Mond (2011)	806 (54.6%)	USA	Cross	Early Adol: M = 12.8 y Late Adol: M = 17.3 y	BMI (both)	Depressive Mood Scale (Symptoms)	Body Dissatisfaction	Body Shape Satisfaction Scale (modified)
Needham (2005)	18795 (50.9%)	USA	Cross	11-21 y	BMI (subjective)	CES-D (19/20 items) (Symptoms)	Self-Rated Health	NR
							Dieting	NR
Pryor (2016)	1221 (54%)	Canada	Long (7 years)	13 y @ follow-up	BMI (objective)	CDI-SF (symptoms)	Teasing (‘peer victimization’)	3 frequency items: being made fun of, hit or pushed, called names by other children
							Body Dissatisfaction (‘desire to be thinner’)	Children’s Pictorial Body Image Scale
Santos (2007)	202 (50%)	USA	Cross	14-19 y	BMI (subjective)	CES-D (symptoms)	Body Dissatisfaction (“body esteem”)	Body Esteem Scale – Revised
							Dieting, Bulimia	EAT-26: dieting & bulimia subscales
Stice (2001)	231 (100%)	USA	Long	13-17 y	BMI (subjective)	Burns Depression Checklist (symptoms)	Body Dissatisfaction	Body Esteem Scale – Revised
							Pressure to be Thin	Perceived Sociocultural Pressure Scale

First Author (Year)	n (% female)	Country	Design (length of follow-up)	Age	Weight Status Measure (Objective vs Subjective)	Depression Measure (Symptoms vs Diagnosis)	Mediator(s)	Mediator Measure(s)
							Thin Ideal Internalization	Ideal-Body Stereotype Scale – Revised
							Dieting	Dutch Restrained Eating Scale
							Bulimic Symptoms	Adult Eating Disorder Examination Questionnaire
terBogt (2006)	7556 (NR)	Nether-lands	Cross	11-16 y	BMI (subjective)	YSR: Anxious/ Depressed subscale (Netherlands) (symptoms)	Weight Perception	1 item: "what do you think of your own body?"
Thompson (1995)	87 (100%)	USA	Long (3 years)	Time 1: 10-15 y Time 2: 13-18 y	Quetlet's Index of Fatness[3] (NR)	CDI (symptoms)	Teasing	Physical appearance related teasing scale
							Body Dissatisfaction	Eating Disorders Inventory: Body Dissatisfaction Scale
							Appearance Dissatisfaction	Self-image Questionnaire for Young Adolescents
Ting (2012)	869 (47%)	Taiwan	Cross	12.2-19.3 y	BMI (both)	CES-D (Clinical cut-off)	Weight Perception	1 item "how do you describe your weight?"
							Weight Concern	1 item from EAT-26: "are you terrified about being overweight?"
								3 items from Eating Attitudes Test (EAT-26)
Vaughan (2010)	10864 (45%)	USA	Long (18 month)	Wave 1: M = 15 y	BMI (both)	CES-D	Dietary Restraint Dieting	1 item "in the past 7 days, which of the following things

First Author (Year)	n (% female)	Country	Design (length of follow-up)	Age	Weight Status Measure (Objective vs Subjective)	Depression Measure (Symptoms vs Diagnosis)	Mediator(s)	Mediator Measure(s)
				Wave 2: ≤19 y		(19/20 items) (symptoms)		did you do in order to lose weight or keep from gaining weight?"
							Weight Perception	1 item "how do you think of yourself in terms of weight?"
Wynne (2016)	225 (50%)	Ireland	Cross	7-12 y	BMI (objective)	CDI-SF (symptoms)	Body Dissatisfaction ('weight change desires')	1 item from Health-Related Behaviour Questionnaire
Xie (2005)	2179 (47%)	China	Cross	11-15 y	BMI (objective)	CES-D Short Form (Mandarin)	Teasing ("Perceived peer isolation")	4 frequency items: being looked down on/being insulted/being isolated/feeling peers did not care
							Perceived Availability of Social Support	3 items: "when you are in need of help who can you count on?", "when you feel pressured/stressed who do you turn to for comfort?", "who accepts you just as you are with all your weaknesses and strengths?"
Xie (2010)	1155 (43.9%)	USA	Long (1 year)	10-15 y	BMI (objective)	5-item adapted CES-D (symptoms)	Body Dissatisfaction	Body Figure Perception Scale (adapted)
Yen (2014)	5252 (53.1%)	Taiwan	Cross	12-18 y	BMI (subjective)	CES-D (Mandarin) (symptoms)	Teasing ('passive bullying victimization'), Active Bullying Victimization,	School Bullying Experience Questionnaire (Chinese)

First Author (Year)	n (% female)	Country	Design (length of follow-up)	Age	Weight Status Measure (Objective vs Subjective)	Depression Measure (Symptoms vs Diagnosis)	Mediator(s)	Mediator Measure(s)
							Passive Bullying Perpetration, Active Bullying Perpetration	

Note. **Design:** Cross = cross-sectional study design, Long = longitudinal study design. **Age:** y = years. **Weight Status Measure:** BMI = body mass index. "subjective" = weight status assessed via self-report; "objective" = weight status assessed by physical measurement. **Depression Measures:** CDI = Children's Depression Inventory; CDI-SF = Children's Depression Inventory Short-Form; CES-D = Center for Epidemiological Studies Depression Scale; MINI = Mini International Neuropsychiatric Interview (version 5.0); YSR = Youth Self-Report. **Mediator Measures:** IPAQ = International Physical Activity Questionnaire; EAT-26 = Eating Attitudes Test.

Measures

Independent Variable: Weight Status. The measurement of weight status was remarkably consistent across reports (Table 3). The majority (14) used BMI as a measure of weight status. Two used BMI coupled with at least one other measure (skinfold thickness, (Chaiton et al., 2009); and waist circumference, dual energy X-ray absorptiometry, in (Gomes et al., 2019). This homogeneity facilitated comparisons across studies. BMI is calculated using an individual's height and weight, which may be assessed objectively (i.e., physical measurements taken by another person), or subjectively via self-report. The latter is likely to be less reliable, particularly among those prone to experiencing dissatisfaction with their weight (Elgar et al., 2005). Eight included reports used objective measures of height and weight (Allen et al., 2006; Bang et al., 2012; Chaiton et al., 2009; Gomes et al., 2019; Pryor et al., 2016; Wynne et al., 2014; Xie et al., 2005, 2010), while five (Needham & Crosnoe, 2005; Santos et al., 2007; Stice & Bearman, 2001; ter Bogt et al., 2006; Yen et al., 2014) exclusively employed the use of self-report. Three reports combined these methods, by taking objective measurements from a subgroup of participants to estimate the accuracy of participants' self-report. Correlations between BMI derived from self-reported and actual height and weight ranged from 0.85 (Mond et al., 2011) to 0.96 (Ting et al., 2012; Vaughan & Halpern, 2010), indicating that despite trends toward underestimation of weight and overestimation of height, both provided reasonably valid measurements of the independent variable.

Dependent Variable: Depression. All but one study assessed the presence of depressive symptoms assessed via self-report questionnaire (Table 3). Self-report measures were validated

and appropriate for child and adolescent samples, though several were adapted and/or translated from their initial format for the purposes of the individual studies, a process which may have compromised their validity. The most frequently used measures were variations of the Center for Epidemiological Studies Depression Scale (Radloff, 1977) in eight reports, followed by variations of the Children's Depression Inventory (Kovacs, 1985) in five reports. While clinical cut-off scores exist for some of these measures, most reports assessed depressive symptoms as a continuous variable (typically a total score) and did not present results separately for those exceeding clinical cut-offs. Only Gomes and colleagues (2019) assessed for clinical levels of depression using psychologist-administered structured interviews (the Mini International Neuropsychiatric Interview version 5.0; (Sheehan et al., 2010), including degree of impairment. This point is crucial for differentiating depressive symptoms, which may be transitory, from clinical depression which by definition is more persistent. Ting (2012) examined depression as a dichotomous outcome, grouped by whether participants' total score on the self-reported CES-D exceeded clinical cut-offs. Given the small number of reports investigating clinical levels of depression, it was not possible to conduct sensitivity analyses comparing mediation effects between clinical and subclinical presentations. However, given evidence that subthreshold depressive symptoms in adolescence are both clinically relevant and predictive of escalation to major depressive disorder (Noyes et al., 2022), differences between these groups were likely minimal.

Design and Statistical Analyses

Thirteen reports employed cross-sectional designs (Allen et al., 2006; Bang et al., 2012; Chaiton et al., 2009; Deepthi & Praveen, 2014; Ge et al., 2001; Mond et al., 2011; Needham & Crosnoe, 2005; Santos et al., 2007; ter Bogt et al., 2006; Ting et al., 2012; Wynne et al., 2014;

Xie et al., 2005; Yen et al., 2014), while six employed longitudinal designs (Gomes et al., 2019; Pryor et al., 2016; Stice & Bearman, 2001; J. K. Thompson et al., 1995; Vaughan & Halpern, 2010; Xie et al., 2010) (Table 3). Of the longitudinal designs, four (Gomes et al., 2019; J. K. Thompson et al., 1995; Vaughan & Halpern, 2010; Xie et al., 2010) assessed variables across only two time points, while two (Pryor et al., 2016; Stice & Bearman, 2001) employed three or more assessment points consistent with best practice in longitudinal mediation analysis (D. A. Cole & Maxwell, 2003). The length of follow-up for longitudinal studies ranged from 10 months to seven years, all of which likely represented sufficient time for depressive symptoms to manifest after exposure to overweight. While baseline levels of depressive symptoms were frequently measured in longitudinal designs, the onset or duration of overweight/obesity exposure was assessed in only two (Pryor et al., 2016; Stice & Bearman, 2001). This represents a shortcoming in the literature, as it remains unclear how long an individual must experience obesity before mediating factors might manifest and risk of depression is increased.

Mediation can be evaluated using several possible statistical approaches, each with their own advantages and disadvantages (see Preacher & Kelley 2011, for thorough review). Six different techniques were employed by included reports: the causal steps approach, the Sobel test, non-parametric bootstrapping, comparison of model fit indices, the difference of coefficients approach, and the proportion mediated approach.

One of the earliest methods – the causal steps approach (Baron & Kenny, 1986) – establishes conditions thought to be necessary for mediation but does not provide an estimate of the magnitude or significance of the mediation effect. It also requires that a significant total effect be established before the indirect effect can be assessed, which has been argued to unnecessarily inflate the risk of Type II error (Fairchild & McDaniel, 2017). Six reports

employed the causal steps approach in combination with a test of the indirect effect (Allen et al., 2006; Bang et al., 2012; Mond et al., 2011; Needham & Crosnoe, 2005; Xie et al., 2005, 2010). The commonly used Sobel test is a method for testing the significance of indirect effects based on the product of coefficients approach, obtained by calculating the ratio of the indirect effect *ab* to its standard error, and evaluating this against a normal distribution (Hayes, 2009). This approach was used by six reports (Allen et al., 2006; Bang et al., 2012; Mond et al., 2011; Xie et al., 2005, 2010; Yen et al., 2014), often as an adjunct to the causal steps approach. However, because this test assumes normality, its significance has been found to be unstable with small samples (Preacher & Kelley, 2011), such as was the case in three reports (Allen et al., 2006; Bang et al., 2012; Mond et al., 2011). The alternative non-parametric bootstrapping approach is more robust to non-normality of the sampling distribution compared to Sobel (Fairchild & McDaniel, 2017) and is more appropriate with smaller samples. Bootstrapping was used, alone or in combination with other effect estimates, in three reports (Gomes et al., 2019; Pryor et al., 2016; Wynne et al., 2014).

Studies employing the use of causal modelling approaches (e.g., structural equation modelling, path analysis) often evaluate the significance of mediated effects by comparing the difference in model fit with and without the direct effect included in the model (Frazier et al., 2004). Mediation is interpreted to have occurred if including the direct effect does not improve model fit. Two reports (Santos et al., 2007; Vaughan & Halpern, 2010) employed the use of this technique to evaluate their multiple mediator models. This is similar in concept to the difference in coefficients approach, wherein the total effect of a predictor on an outcome is compared to the direct effect of the predictor on the outcome while accounting for the effect of the mediator (MacKinnon et al., 2002). The difference in coefficients approach was used in three reports

(Needham & Crosnoe, 2005; ter Bogt et al., 2006; Ting et al., 2012). Both approaches can establish if mediation has occurred, but criteria for evaluating their significance or importance is often unspecified.

Finally, the 'proportion mediated' method entails examining the ratio of the indirect to total effects and using this to test the null hypothesis based on a normal distribution (Fairchild et al., 2009). While widely used and easily interpretable, this estimate is not a true proportion as its value may exceed one (Preacher & Kelley, 2011) which limits its value as an effect estimate. Two reports (Chaiton et al., 2009; Gomes et al., 2019) employed this method to evaluate the significance of mediated effects.

Notably, seven studies reported using more than one approach to calculate the mediation effect, which is an effective strategy to mitigate any limitations of any one approach (Preacher & Kelly, 2011). In contrast, four reports either did not specifically investigate the magnitude and/or significance of the mediated effect (Ge et al., 2001; Stice & Bearman, 2001; J. K. Thompson et al., 1995) or did not report how this was assessed (Deepthi & Praveen, 2014).

Despite these disparate approaches, results were able to be combined in this review in two ways. First, quantitative synthesis entailed pooling estimates of the indirect effect (path *ab* in Figure 2) using standardized regression coefficients, facilitating comparison of effects independent of mediators or measures used. Some studies (particularly those employing the product of coefficients approach) reported *ab* directly; for those employing other approaches, *ab* was calculated based on reported effects for other model pathways using the general mediation formula (1). Second, qualitative synthesis involved a tally of results determined by individual reports to be statistically significant (also known as 'vote counting'), regardless of the approach

used to evaluate it. Thus, differences in mediation techniques did not prohibit combination of their findings in quantitative and qualitative syntheses.

Risk of Bias in Individual Reports

Each individual report was assessed for potential risk of bias using critical appraisal checklists for cross-sectional and cohort studies from the Joanna Briggs Institute adapted for the purposes of this review (see Appendix E and F). Results of these risk of bias assessments are presented in Appendix I. Of the 13 cross-sectional reports evaluated, three were found to have a low risk of bias, nine a moderate risk, and one a high risk of bias. The most common source of bias was inadequate identification of, and controlling for, potential confounders, which occurred in 10 reports. Failure to account for possible confounds increases the risk of spurious associations between model constructs (Frazier et al., 2004) and challenges assumptions made about the causal chain proposed in a given model.

Six reports describing cohort/longitudinal designs were also evaluated, of which two were found to have a low risk of bias, three a moderate risk of bias, and one a high risk of bias (Appendix I). As with the cross-sectional designs, improper identification and exploration of confounders was a notable source of potential bias in three reports (J. K. Thompson et al., 1995; Vaughan & Halpern, 2010; Wynne et al., 2014). An advantage to cohort and longitudinal designs is their potential to determine whether one variable precedes another in time – one of the conditions necessary for establishing the causal inference implicit in mediation analyses (Frazier et al., 2004). Ideally, assessing longitudinal mediation should take place over a minimum of three time points (D. A. Cole & Maxwell, 2003). Three reports (Gomes et al., 2019; J. K. Thompson et al., 1995; Xie et al., 2010) were unable to meet this standard, and two were partially able to do so (Pryor et al., 2016; Vaughan & Halpern, 2010). Reports were eligible for inclusion in quantitative

and qualitative syntheses regardless of their risk of bias to maximize the number of effects available for each outcome. Risk of bias was instead considered when rating the strength of the evidence for each research goal (see Appendix H).

Synthesis Findings

Synthesis findings are presented by research goal and include results of quantitative syntheses (where applicable), qualitative syntheses, and a rating of the strength of the evidence base available for each goal. A summary of specific research questions/outcomes and hypotheses that guided these analyses is outlined in Table 1. A detailed list of effects extracted from the included reports is provided in Table 4, and a list of effects included in each subgroup analysis is outlined in Appendix J.

Table 4

Summary of Mediation Findings from Individual Reports

First Author (Year)	N	Gender	Design	Mediator	Gender Stage Culture	Part of GAM	Med. Class	Test of Mediation	Indirect Effect: Path *a*b*	Total Effect: Path *c*	Other Mediation Effect(s) / Findings	RoB
Allen (2006)	207	Mixed	Cross	Body Dissatisfaction ('weight and shape concern')	No No No	Yes	Cog	Causal Steps + Sobel	0.158*	0.22*		Mod
Bang (2012)	455	Mixed	Cross	(Parental) Teasing	No No No	No	Social	Causal Steps + Sobel	0.092*	0.193*		Mod
Chaiton (2009)	1167	Females	Cross	Pressure to be Thin	Yes Yes No	Yes	Social	Proportion Mediated	0.042 (na)	0.132 (na)	Sig of indirect effect and % mediated only reported for full model	Low
Chaiton (2009)	1127	Males	Cross	Pressure to be Thin	Yes Yes No	Yes	Social	Proportion Mediated	-0.01 (na)	0.01 (na)	Sig of indirect effect and % mediated only reported for full model	Low
Chaiton (2009)	1167	Females	Cross	Body Dissatisfaction	Yes Yes No	Yes	Social	Proportion Mediated	0.14 (na)	0.23 (na)	Sig of indirect effect and % mediated only reported for full model	Low
Chaiton (2009)	1127	Males	Cross	Body Dissatisfaction	Yes Yes	Yes	Social	Proportion Mediated	0.043 (na)	0.063 (na)	Sig of indirect effect and %	Low

First Author (Year)	N	Gender	Design	Mediator	Gender Stage Culture	Part of GAM	Med. Class	Test of Mediation	Indirect Effect: Path *a*b*	Total Effect: Path *c*	Other Mediation Effect(s) / Findings	RoB
					No						mediated only reported for full model	
Chaiton (2009)	1167	Females	Cross	Full model: Body Dissatisfaction + Pressure to be Thin	Yes Yes No	Yes	Social	Proportion Mediated	0.16*	0.26*	Full model sig mediation: accounted for 62% of total effect in females (sig)*	Low
Chaiton (2009)	1127	Males	Cross	Full model: Body Dissatisfaction + Pressure to be Thin	Yes Yes No	Yes	Social	Proportion Mediated	0.03	0.4	% mediated NA due to ns indirect, direct, total effects	Low
Deepthi (2014)	78	Mixed	Cross	Binge Eating	No No No	Yes	Beh	Not Reported	NR*	NR	Authors describe "significant" mediation, only reported β for path *a* and *c'* (sig)*	High
Ge (2001)	NR (All females 1863)	African Ameri-can Females	Cross	Weight Perception	Yes Yes Yes	No	Cog	NA (SEM, maximum likelihood estimate)	-0.11 (na)	NR		Mod
Ge (2001)	NR (All males 1770)	African Ameri-can Males	Cross	Weight Perception	Yes Yes Yes	No	Cog	NA (SEM, maximum likelihood estimate)	-0.059 (na)	NR		Mod

First Author (Year)	N	Gender	Design	Mediator	Gender Stage Culture	Part of GAM	Med. Class	Test of Mediation	Indirect Effect: Path *a*b*	Total Effect: Path *c*	Other Mediation Effect(s) / Findings	RoB
Ge (2001)	NR (All females 1863)	His-panic Ameri-can females	Cross	Weight Perception	Yes Yes Yes	No	Cog	NA (SEM, maximum likelihood estimate)	0.093 (na)	NR		Mod
Ge (2001)	NR (All males 1770)	His-panic Ameri-can males	Cross	Weight Perception	Yes Yes Yes	No	Cog	NA (SEM, maximum likelihood estimate)	0.037 (na)	NR		Mod
Ge (2001)	NR (All females 1863)	Euro-pean Ameri-can females	Cross	Weight Perception	Yes Yes Yes	No	Cog	NA (SEM, maximum likelihood estimate)	0.087 (na)	NR		Mod
Ge (2001)	NR (All males 1770)	Euro-pean Ameri-can males	Cross	Weight Perception	Yes Yes Yes	No	Cog	NA (SEM, maximum likelihood estimate)	0.068 (na)	NR		Mod
Gomes (2019)	2977	Mixed	Long	Physical Activity	Yes No No	No	Beh	Boot-strapping, Proportion Mediated	OR = 1.14 (CI: 0.89-1.47)	OR = 2.68* (CI: 1.11-6.49)	% mediated NR as indirect effect ns; moderation by gender ns	Mod
Gomes (2019)	2977	Mixed	Long	Diet Quality	Yes No No	No	Beh	Boot-strapping, Proportion Mediated	OR = 0.92 (CI: 0.71-1.20)	OR = 2.55* (CI: 1.05-6.11)	% mediated NR as indirect effect ns; moderation by gender NS	Mod

First Author (Year)	N	Gender	Design	Mediator	Gender Stage Culture	Part of GAM	Med. Class	Test of Mediation	Indirect Effect: Path *a*b*	Total Effect: Path *c*	Other Mediation Effect(s) / Findings	RoB
Mond (2011)	440	Females (early adol)	Cross	Body Dissatisfaction	Yes Yes No	Yes	Cog	Causal Steps + Sobel	0.35	0.15	Indirect effect not interpreted (ns total effect; causal steps not satisfied)	Mod
Mond (2011)	366	Males (early adol)	Cross	Body Dissatisfaction	Yes Yes No	Yes	Cog	Causal Steps + Sobel	0.13	0.38*		Mod
Mond (2011)	440	Females (Late adol)	Cross	Body Dissatisfaction	Yes Yes No	Yes	Cog	Causal Steps + Sobel	0.34	0.26	Indirect effect not interpreted (ns total effect; causal steps not satisfied)	Mod
Mond (2011)	366	Males (Late adol)	Cross	Body Dissatisfaction	Yes Yes No	Yes	Cog	Causal Steps + Sobel	0.24*	0.51*		Mod
Needham (2005)	4820	Mixed (Lower grades)	Cross	Self-Rated Health	No Yes No	No	Cog	Causal Steps + Difference in Coefficients	NR	UnStd *b* = 0.07* (0.03)	Indirect effect NR separately (full model only)	Low
Needham (2005)	NR	Mixed (Upper grades)	Cross	Self-Rated Health	No Yes No	No	Cog	Causal Steps + Difference in Coefficients	NR	NR	Indirect effect NR (causal steps not satisfied)	Low
Needham (2005)	9574	Females	Cross	Self-Rated Health	Yes No No	No	Cog	Causal Steps + Difference	NR	UnStd *b* = 0.08*	Indirect effect NR separately	Low

First Author (Year)	N	Gender	Design	Mediator	Gender Stage Culture	Part of GAM	Med. Class	Test of Mediation	Indirect Effect: Path *a*b*	Total Effect: Path *c*	Other Mediation Effect(s) / Findings	RoB
								in Coefficients		(0.02)	(full model only)	
Needham (2005)	9221	Males	Cross	Self-Rated Health	Yes No No	No	Cog	Causal Steps + Difference in Coefficients	NR	UnStd *b* = -0.01 (0.02)	Indirect effect NR (causal steps not satisfied)	Low
Needham (2005)	4820	Mixed (Lower grades)	Cross	Dieting	No Yes No	Yes	Beh	Causal Steps + Difference in Coefficients	UnStd *b* = 0.02 (na)	UnStd *b* = 0.07* (0.03)	Total effect reduced by 14% to ns when dieting added (sig)*	Low
Needham (2005)	NR	Mixed (Upper grades)	Cross	Dieting	No Yes No	Yes	Beh	Causal Steps + Difference in Coefficients	NR	NR	Indirect effect not reported (causal steps not satisfied)	Low
Needham (2005)	9574	Females	Cross	Dieting	Yes No No	Yes	Beh	Causal Steps + Difference in Coefficients	UnStd *b* = 0.04 (na)	UnStd *b* = 0.08* (0.02)	Total effect reduced by 50% to ns when dieting added (sig)*	Low
Needham (2005)	9221	Males	Cross	Dieting	Yes No No	Yes	Beh	Causal Steps + Difference in Coefficients	NR	UnStd *b* = -0.01 (0.02)	Indirect effect NR (causal steps not satisfied)	Low
Pryor (2016)	1221	Mixed (Early Over-weight)	Long	Teasing	Yes No No	No	Social	Boot-strapping	0.03*	0.32*	Sig moderation by overweight onset (sig. mediation for early onset);	Low

First Author (Year)	N	Gender	Design	Mediator	Gender Stage Culture	Part of GAM	Med. Class	Test of Mediation	Indirect Effect: Path *a*b*	Total Effect: Path *c*	Other Mediation Effect(s) / Findings	RoB
											ns moderation by gender	
Pryor (2016)	1221	Mixed (Late Over-weight)	Long	Teasing	Yes No No	No	Social	Boot-strapping	0.004	0.33*	Sig moderation by overweight onset (ns mediation for late onset); ns moderation by gender	Low
Pryor (2016)	1221	Mixed (Early Over-weight)	Long	Body Dissatisfaction	Yes No No	Yes	Cog	Boot-strapping	0.21*	0.32*	NS moderation by overweight onset; ns moderation by gender	Low
Pryor (2016)	1221	Mixed (Late Over-weight)	Long	Body Dissatisfaction	Yes No No	Yes	Cog	Boot-strapping	0.17*	0.33*	NS moderation by overweight onset; ns moderation by gender	Low
Santos (2007)	101	Females	Cross	Body Dissatisfaction	Yes No No	Yes	Cog	Model Fit (path analysis)	0.175 (na)	0.002 (na)	Significance of body dissatisfaction NA as single mediator	Mod
Santos (2007)	101	Males	Cross	Body Dissatisfaction	Yes No No	Yes	Cog	Model Fit (path analysis)	0.122 (na)	-0.110 (na)	Significance of body dissatisfaction	Mod

First Author (Year)	N	Gender	Design	Mediator	Gender Stage Culture	Part of GAM	Med. Class	Test of Mediation	Indirect Effect: Path *a*b*	Total Effect: Path *c*	Other Mediation Effect(s) / Findings	RoB
											NA as single mediator	
Santos[1] (2007)	101	Females	Cross	Full Model: Body dissatisfaction + Dieting + Bulimia	Yes No No	Yes	Cog, Beh, Beh	Model Fit (path analysis	NR	NR	Better model fit with direct effect included: not full mediation; no difference in model fit between males/females	
Santos (2007)	101	Males	Cross	Full Model: Body dissatisfaction + Dieting + Bulimia	Yes No No	Yes	Cog, Beh, Beh	Model Fit (path analysis	NR	NR	Better model fit with direct effect included: not full mediation; no difference in model fit between males/females	
Stice (2001)	227	Females	Long	Body Dissatisfaction	No No No	Yes	Cog	NA (random regression growth curve analysis)	0.011 (na)	NR	No formal test of mediation; female-only sample	Low
Stice[2] (2001)	227	Females		Full Model: Pressure to be Thin + Thin Ideal Internalization + Body Dissatisfaction + Dieting +	No No No	Yes	Social, Cog, Cog, Beh, Beh	Not Assessed (random regression growth curve analysis)	NR	NR	All mediators predicted increases in depressive symptoms; BMI did not predict increases in	

First Author (Year)	N	Gender	Design	Mediator	Gender Stage Culture	Part of GAM	Med. Class	Test of Mediation	Indirect Effect: Path *a*b*	Total Effect: Path *c*	Other Mediation Effect(s) / Findings	RoB
				Bulimic Symptoms							depression, pressure to be thin, or body dissatisfaction.	
terBogt (2006)	7556	Mixed	Cross	Weight Perception	Yes No No	No	Cog	Difference in Coefficients	0.018	0.058	Sig 'partial' mediation; direct effect < total effect with inclusion of weight perception*	Low
Thompson (1995)	87	Mixed	Long	Teasing	No No No	No	Social	NA (path analysis)	-0.057 (na)	NR	Teasing NA as single mediator	High
Thompson (1995)	87	Mixed	Long	Body Dissatisfaction (weight)	No No No	No	Cog	NA (path analysis)	0.0532	NR	Body dissatisfaction NA as single mediator	
Thompson (1995)	87	Mixed	Long	(general) Appearance Dissatisfaction	No No No	No	Cog	NA (path analysis)	-0.337	NR	Appearance dissatisfaction NA as single mediator	
Ting (2012)	859	Mixed	Cross	Weight Perception	No No No	No	Cog	Difference in Coefficients	0.29	0.66	Sig of indirect effect NR; direct effect < total effect with inclusion of weight perception*	Mod

First Author (Year)	N	Gender	Design	Mediator	Gender Stage Culture	Part of GAM	Med. Class	Test of Mediation	Indirect Effect: Path *a*b*	Total Effect: Path *c*	Other Mediation Effect(s) / Findings	RoB
Ting (2012)	859	Mixed	Cross	Weight Concern	No No No	No	Cog	Difference in Coefficients	0.255	0.66	Sig of indirect effect NR; direct effect < total effect with inclusion of weight concern (sig)*	Mod
Ting (2012)	859	Mixed	Cross	Dietary Restraint	No No No	Yes	Beh	Difference in Coefficients	0.1	0.66	Sig of indirect effect NR; direct effect < total effect with inclusion of dietary restraint (sig)*	Mod
Ting (2012)	859	Mixed	Cross	Full Model: Weight Perception + Weight Concern + Dietary Restraint	No No No	No	Cog, Cog, Beh	Model fit (SEM)	NR	NR	Sig partial mediation by weight perception, weight concern, & dietary restraint; good model fit w/o inclusion of direct effect (sig)*	
Vaughan (2010)	5071	Females	Long	Dieting	Yes No No	Yes	Beh	Model Fit (path analysis)	0.016 (na)	-0.004 (na)	Dieting NA as single mediator	Mod
Vaughan (2010)	5793	Males	Long	Dieting	Yes No No	Yes	Beh	Model Fit (path analysis)	0.013 (na)	0.003 (na)	Dieting NA as single mediator	Mod

First Author (Year)	N	Gender	Design	Mediator	Gender Stage Culture	Part of GAM	Med. Class	Test of Mediation	Indirect Effect: Path *a*b*	Total Effect: Path *c*	Other Mediation Effect(s) / Findings	RoB
Vaughan (2010)	5071	Females	Long	Weight Perception	Yes No No	No	Cog	Model Fit (path analysis)	-0.01 (na)	0.03 (na)	Weight perception NA as single mediator	Mod
Vaughan (2010)	5793	Males	Long	Weight Perception	Yes No No	No	Cog	Model Fit (path analysis)	-0.005 (na)	-0.015 (na)	Weight perception NA as single mediator	Mod
Vaughan (2010)	10864	Mixed	Long	Full Model: Weight Perception + Dieting	Yes No No	Yes	Cog, Beh	Model Fit (path analysis)	NR	NR	Sig mediation via weight perception + dieting in full sample (Degraded model fit when direct effect included); ns moderation by gender; indirect effect sig. in females and males (sig)*	Mod
Wynne (2016) Ireland	252	Mixed	Cross	Body Dissatisfaction	Yes Yes No	Yes	Cog	Boot-strapping	0.171 (na)	0.065 (na)	ns moderation by gender or age	Mod
Xie (2005)	1023	Females	Cross	Teasing	Yes No No	No	Social	Causal Steps + Sobel	0.142*	0.244*	Sig gender x 'perceived availability of social support'	Mod

First Author (Year)	N	Gender	Design	Mediator	Gender Stage Culture	Part of GAM	Med. Class	Test of Mediation	Indirect Effect: Path *a*b*	Total Effect: Path *c*	Other Mediation Effect(s) / Findings	RoB
											moderation: (sig. mediation only among females with low support)	
Xie (2005)	1156	Males	Cross	Teasing	Yes No No	No	Social	Causal Steps + Sobel	-0.087	0.104	Sig gender x 'perceived availability of social support' moderation; NS mediation among males (high or low levels of support)	Mod
Xie (2005)	1023	Females	Cross	Perceived Availability of Social Support	Yes No No	No	Social	Causal Steps + Sobel	NR	NR	NS mediation, results NR.	Mod
Xie (2005)	1156	Males	Cross	Perceived Availability of Social Support	Yes No No	No	Social	Causal Steps + Sobel	NR	NR	NS mediation, results NR.	Mod
Xie (2010)	648	Females	Long	Body Dissatisfaction	Yes No Yes	Yes	Cog	Causal Steps + Sobel	0.06*	-0.01	Authors report sig. mediation via statistical 'suppression'[3]	Mod
Xie (2010)	507	Males	Long	Body Dissatisfaction	Yes No Yes	Yes	Cog	Causal Steps + Sobel	-0.01	0.11*		Mod
Xie (2010)	201	Asian Females	Long	Body Dissatisfaction	Yes No	Yes	Cog	Causal Steps + Sobel	0.05*	-0.09*	Sig ethnicity x gender	Mod

First Author (Year)	N	Gender	Design	Mediator	Gender Stage Culture	Part of GAM	Med. Class	Test of Mediation	Indirect Effect: Path *a*b*	Total Effect: Path *c*	Other Mediation Effect(s) / Findings	RoB
					Yes						moderation: Mediation only sig for Asian females	
Xie (2010)	174	Asian Males	Long	Body Dissatisfaction	Yes No Yes	Yes	Cog	Causal Steps + Sobel	0.008	0.15*	Sig ethnicity x gender moderation: mediation ns for Asian males	Mod
Xie (2010)	447	Hispanic Females	Long	Body Dissatisfaction	Yes No Yes	Yes	Cog	Causal Steps + Sobel	0.05	0.01	Sig ethnicity x gender moderation: mediation ns for Hispanic females	Mod
Xie (2010)	333	Hispanic Males	Long	Body Dissatisfaction	Yes No Yes	Yes	Cog	Causal Steps + Sobel	-0.04	0.11	Sig ethnicity x gender moderation: mediation ns for Hispanic males	Mod
Xie (2010)	NR	High Accul-turation Females	Long	Body Dissatisfaction	Yes No Yes	Yes	Cog	Causal Steps + Sobel	0.08*	-0.07*	Sig acculturation x gender moderation: Mediation only sig. for females with high acculturation	Mod

First Author (Year)	N	Gender	Design	Mediator	Gender Stage Culture	Part of GAM	Med. Class	Test of Mediation	Indirect Effect: Path *a*b*	Total Effect: Path *c*	Other Mediation Effect(s) / Findings	RoB
Xie (2010)	NR	High Accul-turation Males	Long	Body Dissatisfaction	Yes No Yes	Yes	Cog	Causal Steps + Sobel	-0.07	0.04	Sig acculturation x gender moderation: Mediation ns for males with high acculturation	Mod
Xie (2010)	NR	Low Accul-turation Females	Long	Body Dissatisfaction	Yes No Yes	Yes	Cog	Causal Steps + Sobel	0.05	0.07	Sig acculturation x gender moderation: Mediation ns for females with low acculturation	Mod
Xie (2010)	NR	Low Accul-turation Males	Long	Body Dissatisfaction	Yes No Yes	Yes	Cog	Causal Steps + Sobel	0.05	0.14*	Sig acculturation x gender moderation: Mediation ns for males with low acculturation	Mod
Yen (2014)	2789	Females	Cross	Teasing (‘passive bullying victimization’)	Yes No No	No	Social	Sobel	0.029*	NR	ns moderation by gender	Mod
Yen (2014)	2463	Males	Cross	Teasing (‘passive bullying victimization’)	Yes No No	No	Social	Sobel	0.029*	NR	ns moderation by gender	Mod

First Author (Year)	N	Gender	Design	Mediator	Gender Stage Culture	Part of GAM	Med. Class	Test of Mediation	Indirect Effect: Path *a*b*	Total Effect: Path *c*	Other Mediation Effect(s) / Findings	RoB
Yen (2014)	2789	Females	Cross	Active Bullying Victimization	Yes No No	No	Social	Sobel	0.01*	NR	ns moderation by gender	Mod
Yen (2014)	2463	Males	Cross	Active Bullying Victimization	Yes No No	No	Social	Sobel	0.01*	NR	ns moderation by gender	Mod
Yen (2014)	2789	Females	Cross	Passive Bullying Perpetration	Yes No No	No	Beh	Sobel	0.007*	NR	ns moderation by gender	Mod
Yen (2014)	2463	Males	Cross	Passive Bullying Perpetration	Yes No No	No	Beh	Sobel	0.007*	NR	ns moderation by gender	Mod
Yen (2014)	5252	Mixed	Cross	Active Bullying Perpetration	No No No	No	Beh	Sobel	0.003	NR	Moderation by gender NA b/c ns indirect effect	Mod

Note. **Author (year) in BOLD** = effect estimate included in quantitative synthesis. Cross = cross-sectional study design; Long = longitudinal study design; RoB = risk of bias rating; Mod = indicates a moderate risk of bias rating; Beh = behavioural mediator; Cog = cognitive mediator; sig = statistically significant finding as described by report authors; ns = non-significant; NR = not reported; NA = not assessed; OR = odds ratio; UnStd = unstandardized

[1] 'dieting' and 'bulimia' part of full model, but indirect and total effects were not reported separately and are thus not presented here.

[2] 'pressure to be thin', 'thin ideal internalization', 'dieting', and 'bulimic symptoms' all part of full model investigated, but indirect and total effects were not reported separately and are thus not reported here.

[3] 'Suppression' in statistical mediation refers to a circumstance when the direct and indirect effects are of similar magnitude but opposite signs, resulting in a near-zero total effect (Fairchild & McDaniel, 2017)

*Statistically significant finding as described by report authors; (na) statistical significance not assessed by report authors

Research Goal 1: Mediation Effects of All Psychological, Social, and Behavioural Variables

The first goal was to test the hypothesis that the combined effects of all psychological, social, and behavioural variables captured in this review significantly mediate the relationship between weight status and depression in children and adolescents. To accomplish this, two random-effects meta-regressions were conducted to determine the magnitude and significance of a) the average overall indirect effect of all eligible mediators, and b) the average overall total effect of weight status on depression.

A total of 22 effects describing five different mediators were eligible for inclusion in quantitative synthesis. Meta-analytic findings for the pooled indirect and total effects of weight status on depression are presented in Tables 5 and 6, respectively.

The average overall indirect effect for all mediators combined was small but significant (M = 0.029; p = .005; n = 22). The lack of reported within-study variability prohibited the use of statistical tests for quantifying heterogeneity. Instead, visual inspection of the dispersion across individual study estimates (represented in Figures 4 and 5) was used to assess the consistency of observed effects. The upper- and lower-bound 95% confidence intervals for the average effects were also used as a general proxy for heterogeneity, as greater heterogeneity yields a wider ranging confidence interval. Using this metric, the average indirect effect demonstrated an acceptable degree of precision and statistical heterogeneity (95% CI 0.001 to 0.047). In support of review hypotheses, this finding indicates that the psychosocial and behavioural variables investigated within the eligible literature play a small but significant role in mediating the relationship between weight status and depression in young people.

Table 5

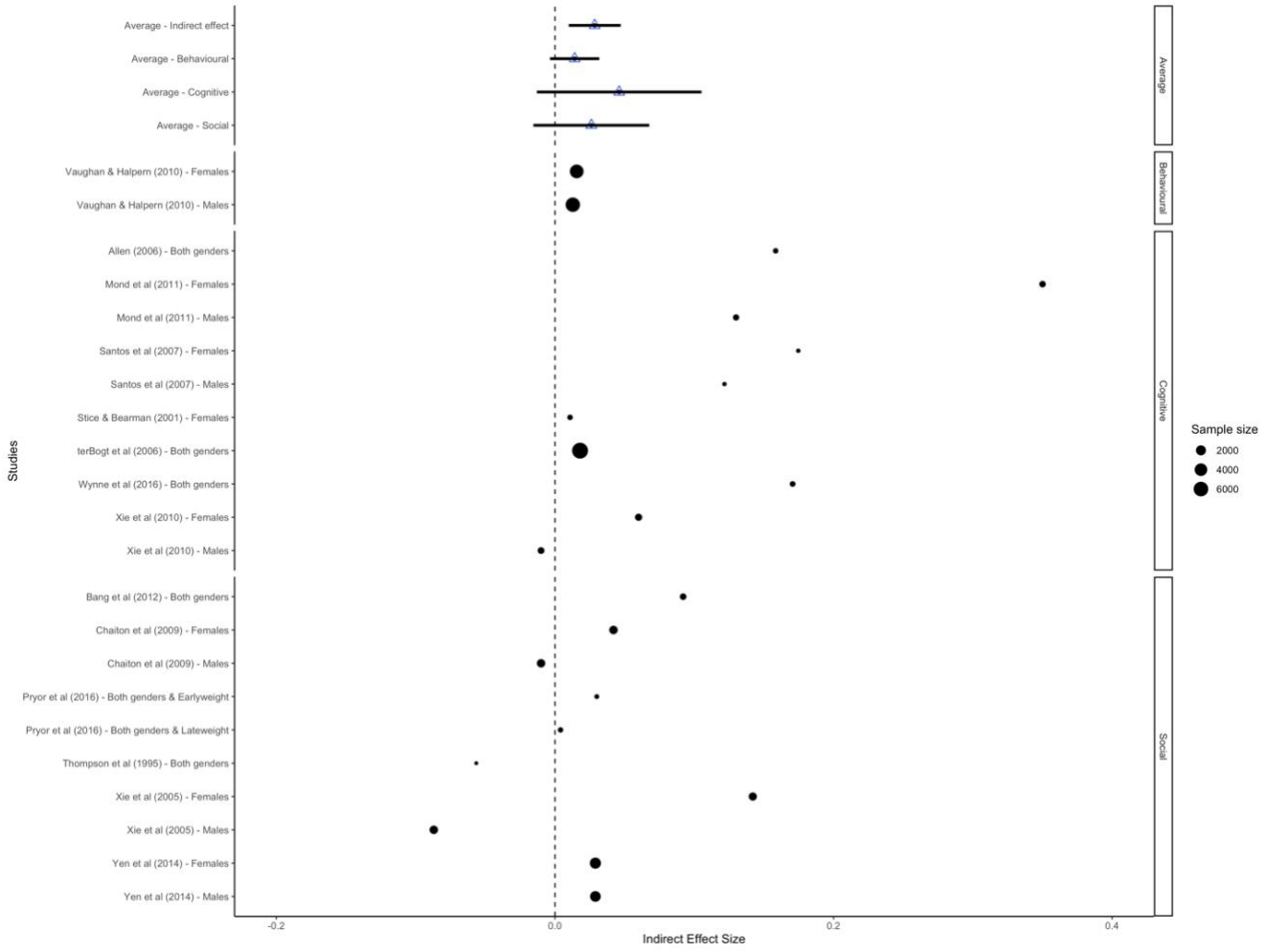
Quantitative Syntheses of Indirect Effects

Effect	Mean ES	n	*p*-value	CI Lower	CI Upper
Average overall indirect effect					
All mediators	0.029	22	.005*	0.01	0.047
Subgroup analysis: Gender (females, males)					
Females	0.05	8	.066	-0.004	0.103
Males	0.008	7	.566	-0.023	0.039
Inferential omnibus test between females and males			.134		
Subgroup analysis: GAM mediators (variables part of GAM, non-GAM variables)					
GAM studies	0.033	13	.038*	0.002	0.065
Non-GAM studies	0.024	9	.093	-0.005	0.052
Inferential omnibus test between GAM and non-GAM studies			.611		
Subgroup analysis: Interaction between GAM mediators and gender					
GAM studies – females	0.045	6	.180	-0.029	0.118
GAM studies – males	0.015	5	.126	-0.007	0.036
Non-GAM studies – females	0.059	2	.409	-0.505	0.623
Non-GAM studies – males	-0.008	2	.899	-0.649	0.633
Inferential test Omnibus test (interaction)			.492		
Subgroup analysis: Mediator class (cognitive, social, behavioural)					
Cognitive	0.046	10	.112	-0.013	0.105
Social	0.026	10	.19	-0.016	0.068
Behavioural	0.014	2	.063	-0.004	0.032
Inferential omnibus test between cognitive and social mediators (only)			.539		
Inferential omnibus test between cognitive, social, and behavioural mediators			.416		

Note. CI = confidence interval; ES = Effect size; GAM = gender additive model of depression (Stice & Bearman, 2001); n = number of effects (outcomes) included in analysis; *statistically significant *p*-value

Figure 4

Average Overall Indirect Effect of All Psychosocial and Behavioural Mediators



Total effects – estimates of the overall effect of weight status on depressive symptoms without accounting for the effect of any mediating variables – were also pooled in meta-analysis. The average overall total effect of weight status on depression across all mediation studies was significant, with a small mean effect size of 0.056 (p = .013; 95% CI: 0.013 to 0.099; n = 18). The confidence interval limits indicated this estimate to be reasonably precise. This finding confirms the existence of a significant relationship between weight status and depression in children and adolescents within the studies included in the review. The proportion mediated (P_M), which expresses a ratio of the indirect effect to the total effect ($P_M = ab/c$), was 0.518, suggesting that this collection of mediators accounts for approximately half of the small-to-medium total effect of weight on depression identified in this review. However, as P_M does not represent a true proportion (i.e., its value can exceed one or be negative), researchers have cautioned it should not be interpreted as such (Preacher & Kelley, 2011).

Table 6

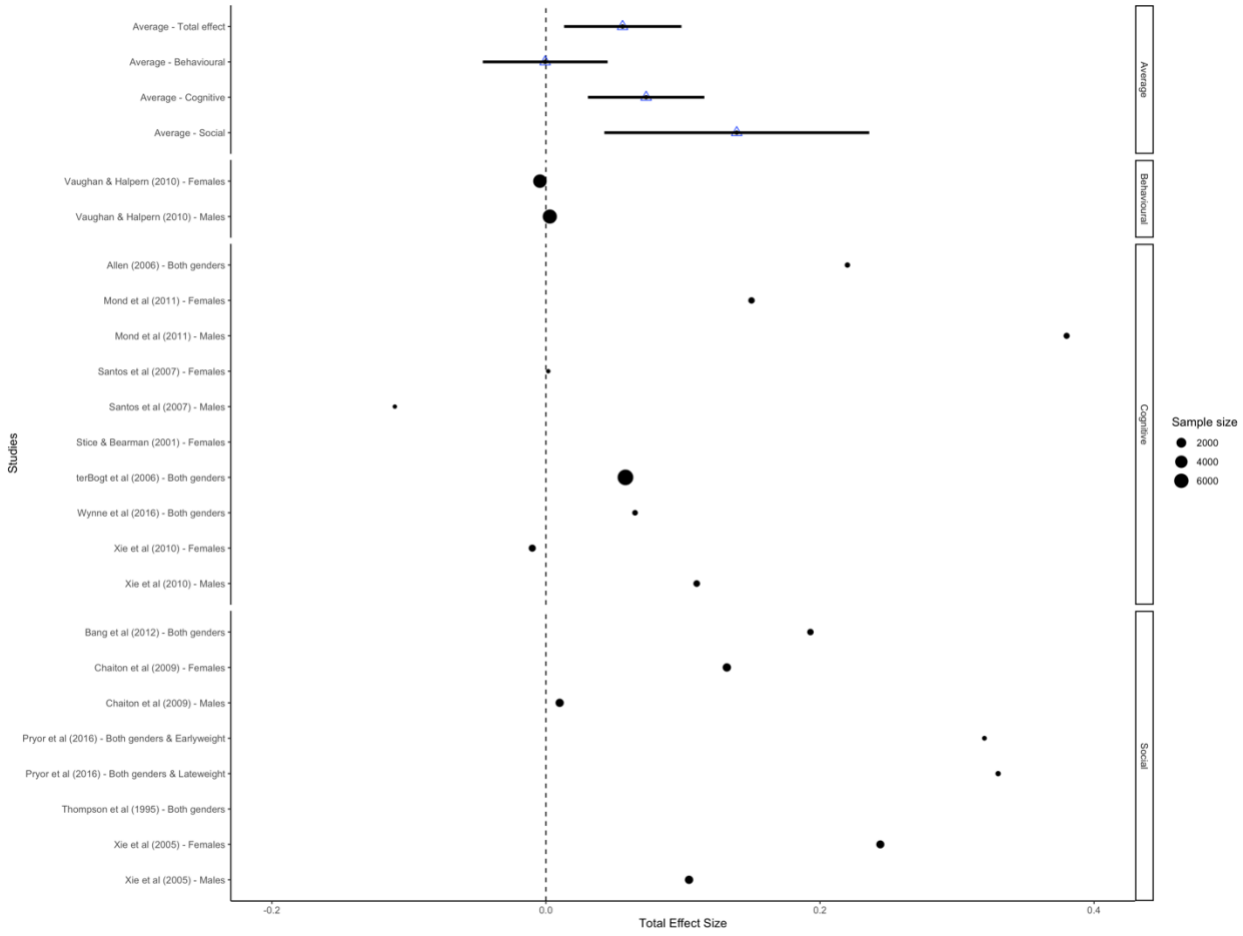
Quantitative Syntheses of Total Effects

Effect	Mean ES	n	*p*-value	CI Lower	CI Upper
Average overall total effect					
All eligible reports	0.056	18	.013*	0.013	0.099
Subgroup analysis: Gender (females, males)					
Females	0.052	6	.32	-0.069	0.174
Males	0.037	6	.281	-0.041	0.115
Inferential omnibus test between females and males			.788		
Subgroup analysis: GAM mediators (variables part of GAM, non-GAM variables)					
GAM studies	0.029	12	.17	-0.015	0.074
Non-GAM studies	0.096	6	.039*	0.007	0.184
Inferential omnibus test between GAM and non-GAM studies			.109		
Subgroup analysis: Mediator class (cognitive, social, behavioural)					
Cognitive	0.073	9	.004*	0.031	0.116
Social	0.139	7	.012*	0.043	0.236
Behavioural	-0.001	2	.901	-0.046	0.045
Inferential omnibus test between cognitive and social mediators (only)			.149		
Inferential omnibus test between cognitive, social, and behavioural mediators			<.001*		

Note. CI = confidence interval; ES = Effect size; GAM = gender additive model of depression (Stice & Bearman, 2001); n = number of effects (outcomes) included in analysis
*Statistically significant *p*-value

Figure 5

Average Overall Total Effect of Weight Status on Depression



A total of 16 different mediators were investigated among the 19 included reports. Ten mediators (diet quality, active bullying perpetration, passive bullying perpetration, active bullying victimization, weight concern, general appearance dissatisfaction, self-rated health, perceived availability of social support, physical activity, and thin ideal internalization) were investigated by single reports. Mediation models were examined in one of two ways: evaluating the role of single mediators ($k = 11$) or evaluating multiple mediator models wherein intermediate variables have downstream effects on other mediating variables ($k = 8$). Although sixty estimates of the indirect effects of psychosocial and behavioural mediators were reported across all reports, only 34 of these were evaluated for statistical significance and therefore eligible for consideration in qualitative synthesis. Of these, 21 (62%) found evidence of significant evidence of mediation (Allen et al., 2006; Bang et al., 2012; Deepthi & Praveen, 2014; Mond et al., 2011; Needham & Crosnoe, 2005; Pryor et al., 2016; ter Bogt et al., 2006; Ting et al., 2012; Xie et al., 2005, 2010; Yen et al., 2014) (see Tables 4 and 7). These represent a range of mediator effects which are explored further in subgroup analyses and qualitative syntheses below. Finally, 15/22 (68%) of the total effects across reports (that conducted significance testing) demonstrated a statistically significant effect of weight status on depression (without controlling for mediator effects).

Conclusions and Strength of the Evidence. These findings support the existence of a link between weight status and depression among the reports included in this review, and that this link is mediated by psychological, social, and behavioural mediators that were investigated. The strength of this evidence was rated *low-to-moderate,* suggesting this result is likely stable but may change with additional high-quality evidence. This rating was primarily reflective of

inconsistency among findings (Table 7), which may have been the result of differences across subgroups of participants.

Table 7

Synthesis Findings and Strength of Evidence Ratings

Goal	Outcome (Question)	#Reports[1] (#Effects)[2] (N)[3]	Summary of Findings	Risk of Bias (sig)[4]	Domain Scores
1	Do psychological, social, and behavioural variables mediate the relationship between weight status and depression in children and adolescents?	18 (43) (55,466)	**Quantitative synthesis:** Small, sig average overall indirect effect of all mediators (M = 0.029; *p* = .005; *n* = 22). **Qualitative synthesis:** 21/34 (62%) found sig mediation effect (pooled mediators) **Conclusion:** The combination of psychological, social, and behavioural variables investigated by included reports probably mediate the relationship between weight status and depression in young people to a small degree	Low: 12(6) Mod: 29(14) High: 2(1)	**Limitations**: Moderate (67% of effects from reports with moderate risk of bias) **Directness**: Indirect (12/43 effects from longitudinal designs **Consistency**: Inconsistent (<70% effects found sig. mediation) **Precision**: Precise (acceptable confidence interval; >50% of effects in qualitative synthesis were adequately powered) **Overall**: *Low-Moderate* (adequate # effects; inconsistent however many effects represented different subsamples from individual reports, suggesting differences may be due to subgroup effects; low number of longitudinal designs; conclusion likely stable but may change with additional high-quality evidence)
2	Is the average overall indirect effect moderated by gender?	12 (22) (53,532[5])	**Quantitative synthesis:** No sig moderation by gender (*p* = .13). Marginally	Low: 9(2)	**Limitations**: Moderate (59% of effects from reports with moderate risk of bias)

Goal	Outcome (Question)	#Reports[1] (#Effects)[2] (N)[3]	Summary of Findings	Risk of Bias (sig)[4]	Domain Scores
			sig effects for females (M = 0.05; *p* = .07; 95% CI: 0.004 to 0.103; *n* = 8), n.s. for males (M = 0.01; *p* = .57; 95% CI: -0.023 to 0.039; *n* = 7). High heterogeneity in both, especially high in females. **Qualitative synthesis:** 13/18 (72%) found no sig moderation by gender; 10 of which found sig mediation for both males and females. **Conclusion**: No clear evidence that gender moderates the mediation pathways	Mod: 13(3) High: 0(0)	**Directness**: Indirect (assessment of gender valid; 10/22 effects from reports with longitudinal designs) **Consistency**: Consistent (>70% effects in qualitative synthesis in same direction, same finding as quantitative subgroup analysis) **Precision**: Precision unclear (wide confidence intervals for each group, >50% n.s. effects were adequately powered) **Overall Rating**: *Moderate*.
2	Is the average overall indirect effect moderated by developmental stage?	3 (4) (21,895)	**Quantitative synthesis:** No subgroup analysis conducted (insufficient # effects) **Qualitative synthesis:** All 3 reports used age as proxy for developmental	Low: 2(1) Mod: 2(1) High: 0(0)	**Limitations**: Low-Moderate (2/4 effects rated low risk of bias) **Directness**: Indirect (age used as proxy for pubertal development) **Consistency**: Inconsistent (all reports found results in different directions)

Goal	Outcome (Question)	#Reports[1] (#Effects)[2] (N)[3]	Summary of Findings	Risk of Bias (sig)[4]	Domain Scores
			stage; conflicting findings across all effects (1 high powered report found effect for younger participants only). **Conclusion**: No direct evidence whether developmental stage moderates mediated effects; conflicting findings re: age.		**Precision**: Precise (no meta-analytic confidence intervals available, included reports adequately powered to detect effects) **Overall Rating**: *Insufficient* (few effects available, conflicting findings; despite low limitations and good precision, no reports used a measure of pubertal development sensitive enough to properly evaluate the hypothesis)
2	Is the average overall indirect effect moderated by culture?	2[6] (14) (4,788)	**Quantitative synthesis:** No subgroup analysis conducted **Qualitative synthesis:** Only one report[6] formally evaluated moderation by culture; found interaction between gender and both ethnicity and acculturation (2 effects). Second report found gender + ethnicity moderated the relationship between weight perception and depression.	Low: 0(0) Mod: 14(2) High: 0(0)	**Limitations**: Moderate **Directness**: Direct (ethnicity and acculturation adequately assessed; report conducting formal mediation employed longitudinal design) **Consistency**: Consistency unknown (only 1 report conducted formal moderation of mediated effect) **Precision**: Precise (no meta-analytic confidence intervals available, included adequately powered reports)

Goal	Outcome (Question)	#Reports[1] (#Effects)[2] (N)[3]	Summary of Findings	Risk of Bias (sig)[4]	Domain Scores
			Conclusion: Very limited support for moderation by ethnicity as proxy for culture		**Overall Rating**: *Insufficient* (only 1 report with formal mediation analysis)
3	Do GAM variables mediate the relationship between weight status and depression? Is this effect significantly stronger than the indirect effect of other psychosocial and behavioural mediators not in the GAM?	13[7] (29) (37,047[5])	**Quantitative synthesis:** No sig moderation by inclusion in GAM (p = 0.611). Average indirect effect of GAM mediators was small and sig (M = 0.03; p = 0.038; 95% CI: 0.002 to 0.065; n = 13), non-GAM mediators small and n.s. (M = 0.02; p = 0.093; n = 9; 95% CI: -0.005 to 0.052). **Qualitative synthesis:** *Multi-mediator models*: 3/4 found evidence of mediation. None assessed all original GAM variables. *Single mediator effects*: 9/15 (60%) reported effects of GAM variables were sig.; no effects reported for	*Full model*: Low: 3(1) Mod: 3(3) High: 0 *Single mediator*: Low: 9(4) Mod: 13(4) High: 1(1)	**Limitations**: Moderate (55% effects from reports rated as moderate risk of bias) **Directness**: Indirect (2 GAM mediators not represented; reports investigating full model did not include all mediators) **Consistency**: Inconsistent (61% effects in qualitative synthesis found evidence in support of the GAM) **Precision**: Precise (narrow meta-analytic confidence interval for indirect effect of GAM mediators; >50% adequate power/sample size) **Overall Rating**: *Low* (despite a sig average indirect effect with acceptable precision, and an adequate number of data points in qualitative synthesis, not all model constructs were evaluated, representing a shortcoming in the

Goal	Outcome (Question)	#Reports[1] (#Effects)[2] (N)[3]	Summary of Findings	Risk of Bias (sig)[4]	Domain Scores
			'pressure to be thin' or 'thin ideal internalization', so full model not represented. **Conclusion:** GAM mediators that were investigated had a small mediating effect on the relationship between weight status and depression, but not significantly more so than other variables.		strength of the evidence base; more evidence is necessary before considering this finding to be stable/close to true effect).
3	Is the indirect effect of GAM variables moderated by gender?	8 (13) (35,568[5])	**Quantitative synthesis:** Formal subgroup analysis underpowered (insufficient # effects in each group). Exploratory subgroup analysis: no evidence of moderation by gender; n.s. indirect effects for males and females. **Qualitative synthesis:** *Full model*: 2/3 reports found no moderation, with sig effects for males and females. 1/3 found sig	*Full model*: Low: 1(1) Mod: 2(0) High: 0(0) *Individual mediators*: Low: 5(1)	**Limitations**: Low-Moderate (54% effects from reports rated moderate risk of bias) **Directness**: Indirect (valid measurement of moderator, 4/9 effects from longitudinal designs; moderation by gender for full model not investigated by any report) **Consistency**: Inconsistent (44% effects found sig evidence of moderation by gender) **Precision**: Precision Unknown (wide confidence intervals for meta-analytic subgroups; most individual

Goal	Outcome (Question)	#Reports[1] (#Effects)[2] (N)[3]	Summary of Findings	Risk of Bias (sig)[4]	Domain Scores
			effects for females not males. *Individual mediators*: 3/6 (50%) outcomes found no sig moderation by gender, 2 found sig effects for females only (in support of GAM premise), and 1 found sig effects for older adolescent males only. **Conclusion**: No clear evidence that the mediated effect of GAM variables is moderated by gender	Mod: 5(2) High: 0(0)	reports adequately powered to detect effects) **Overall Rating**: *Low* (small majority of effects found no evidence of moderation by gender; no reports evaluated the full model and therefore could not properly assess how gender impacts all model pathways; subgroup analyses were exploratory and imprecise)
3	Is the indirect effect of GAM variables moderated by developmental stage?	3 (4) (21,895)	**Quantitative synthesis:** No subgroup analysis conducted (insufficient # effects) **Qualitative synthesis:** 2 effects found sig moderation by age group, but in opposing directions; 1 report examining full GAM found no moderation by age	*Full model*: Low: 1(0) Mod: 0(0) High: 0(0) *Individual mediators*: Low:	**Limitations**: Low-Moderate (2/4 effects from reports rated as having low risk of bias) **Directness**: Indirect (grade level and age used as proxies for developmental stage) **Consistency**: Inconsistent (no similarity in effect across reports) **Precision**: Precise (no meta-analytic confidence interval

Goal	Outcome (Question)	#Reports[1] (#Effects)[2] (N)[3]	Summary of Findings	Risk of Bias (sig)[4]	Domain Scores
				1(1)	available; adequate power/sample size across reports)
			Conclusion: Unclear whether developmental stage/age moderates the mediation effects of GAM variables	Mod: 2(1)	**Overall**: *Insufficient* (evidence is too inconsistent to estimate an effect)
				High: 0(0)	
3	Is the indirect effect of GAM variables moderated by culture?	1 (8) (1,155)	**Quantitative synthesis:** No subgroup analysis conducted (insufficient # effects)	*Full model*: Low: 0	**Limitations**: Moderate (all effects from one report rated moderate risk of bias)
				Mod: 0	**Directness**: Indirect (validated measure of acculturation, ethnicity acceptable proxy for culture; single report employed longitudinal design; however, only body dissatisfaction examined and not full GAM)
			Qualitative synthesis: Only 1 report describing 8 effects for different subgroups of participants. Sig interaction between gender (female) and both culture (Asian) and acculturation (high).	High: 0	
				Individual mediators: Low: 0(0)	**Consistency**: Consistency unknown (all effects from the same report)
				Mod: 8(2)	**Precision**: Precision unknown (no meta-analytic confidence interval available; some subgroups adequate power/sample, others not or not reported)
			Conclusion: The mediating effect of body dissatisfaction *may* vary based on the interaction of gender and culture/level of acculturation, but evidence is very limited. No evidence	High: 0(0)	
					Overall: *Insufficient* (only examined by one report)

Goal	Outcome (Question)	#Reports[1] (#Effects)[2] (N)[3]	Summary of Findings	Risk of Bias (sig)[4]	Domain Scores
			whether the full GAM is moderated by culture/ethnicity.		
4	Which class of mediator (i.e., cognitive, social, behavioural) has the strongest average indirect effect? Are these average indirect effects significantly different from one another?	14 (22) (32,734)	**Quantitative synthesis:** No sig difference in mean indirect effects between classes (p = .416). Slightly higher effect of cognitive than social or behavioural mediators, none statistically significant. **Conclusion:** No mediator class had a significantly stronger mediating effect than the others.		**Limitations**: Moderate (68% of effects from reports rated as having moderate risk of bias) **Directness**: Indirect (8/22 effects from longitudinal designs) **Consistency**: n/a **Precision**: n/a **Overall**: *Low* (small range of variables in each category included in quantitative synthesis, lack of difference not representative of all cognitive, social, and behavioural mediators)
4	Do cognitive variables mediate the relationship between weight status and depression in children and adolescents?	9 (16) (12,472)	**Quantitative synthesis:** Small, n.s. average indirect effect with low precision (M = 0.05; p = .112; 95% CI: -0.013 to 0.105, n = 10). **Qualitative synthesis:**	Low: 4(3) Mod: 12(3) High: 0(0)	**Limitations**: Moderate (75% of effects from reports rated as moderate risk of bias) **Directness**: Indirect (only 4 mediators evaluated; 5/16 from longitudinal designs) **Consistency**: Inconsistent (quantitative and qualitative results conflict; <70% of effects in

Goal	Outcome (Question)	#Reports[1] (#Effects)[2] (N)[3]	Summary of Findings	Risk of Bias (sig)[4]	Domain Scores
			8/12 (67%) sig effects (body dissatisfaction, weight perception, weight concern) **Conclusion***:* Cognitive variables likely play a mediating role, but available evidence precludes a conclusion about the magnitude of their effect.		qualitative synthesis found evidence of effect) **Precision**: Precise (wide confidence interval; >50% of effects in qualitative synthesis were adequately powered to detect effects; 2 n.s. results due to restrictions of causal steps approach which may lead to reduced power to detect effects) **Overall**: *Low*. (small majority of effects showed sig. mediation, though quantitative failed to achieve significance; relatively few cognitive mediators evaluated for significance so conclusions about the scope are limited; additional evidence would increase confidence in stability of this finding)
4	Do social variables mediate the relationship between weight status and depression in children and adolescents?	6 (14) (11,488)	**Quantitative synthesis:** Small, n.s. result with low precision (M = 0.03; p = .19; 95% CI: -0.016 to 0.068; k = 10) **Qualitative synthesis:**	Low: 4(1) Mod: 9(6) High: 1(0)	**Limitations**: Moderate (9/14 effects from reports rated as having a moderate risk of bias) **Directness**: Indirect (3/14 effects from longitudinal reports) **Consistency**: Inconsistent (<70% of effects assessed for statistical

Goal	Outcome (Question)	#Reports[1] (#Effects)[2] (N)[3]	Summary of Findings	Risk of Bias (sig)[4]	Domain Scores
			7/11 effects found evidence of sig mediation (4 from same sample), all describing a single construct (teasing) **Conclusion***:* Some evidence that social variables may mediate the weight status-depression relationship to a small degree.		significance found evidence of an effect) **Precision**: Precision Unclear (wide confidence interval in subgroup analysis; 86% effects in qualitative synthesis adequately powered) **Overall**: *Low* (meta-analysis failed to identify a sig effect, qualitative synthesis found some evidence; proportion of n.s. results likely influenced by 2 effects of 'perceived availability of social support' which may have provided a suppression effect and contributed to non-significant findings)
4	Do behavioural variables mediate the relationship between weight status and depression in children and adolescents?	6 (13) (38,835[5])	**Quantitative synthesis:** Small effect (M = 0.01; *p* = .063) based on only 2 effects of same variable (dieting) from same report. **Qualitative synthesis:** 6 different mediators investigated: 6/11 (55%) effects sig (binge eating, dieting, passive bullying)	Low: 4(2) Mod: 8(3) High: 1(1)	**Limitations**: Moderate (62%effects from reports rated as having a moderate risk of bias) **Directness**: Indirect (meta-analysis restricted to only 1 behavioural mediator, 9/13 effects from cross-sectional reports) **Consistency**: Inconsistent (<70% of effects found evidence of sig mediation) **Precision**: Precise (wide confidence interval from meta-analytic finding,

Goal	Outcome (Question)	#Reports[1] (#Effects)[2] (N)[3]	Summary of Findings	Risk of Bias (sig)[4]	Domain Scores
			Conclusion: Some evidence that behavioural variables may mediate the weight status-depression relationship.		based on only 2 effects from same sample; 10/11 qualitative effects from reports with adequate statistical power) **Overall**: *Low* (variety of mediators investigated; quantitative subgroup analysis underpowered, as based on only two effect effects from same sample; 4 mediators estimated by <2 effects)
	What specific individual psychological, social, and/or behavioural variables significantly mediate the relationship between weight status and depression in children and adolescents?		**Quantitative synthesis:** No quantitative syntheses performed for individual mediators, due to overlap with mediator class subgroup analysis		
4		4 (9) (3,389)	*Body Dissatisfaction* **Qualitative Synthesis:** 5/9 effects sig; 2 of n.s. effects based on causal steps approach.	Low: 2(2) Mod: 7(3)	**Limitations**: Moderate (78% of effects were from reports rated as having a moderate risk of bias) **Directness**: Indirect (despite little overlap in assessment tools, reasonable validity to assess body

Goal	Outcome (Question)	#Reports[1] (#Effects)[2] (N)[3]	Summary of Findings	Risk of Bias (sig)[4]	Domain Scores
				High: 0(0)	dissatisfaction construct; 4/9 effects from longitudinal reports)
			Conclusion: Body dissatisfaction may mediate the relationship between weight status and depression.		**Consistency**: Inconsistent (<70% of effects found sig mediation for body dissatisfaction)
					Precision: Imprecise (just under 50% of effects were adequately powered)
					Overall: *Low* (acceptable number of effect effects available; most n.s. effects represent different subsamples from same report, which lacks power due to causal steps approach).
4		4 (9) (9,107)	*Teasing*	Low: 2(1)	**Limitations**: Moderate (78% effects were from reports rated as having a moderate risk of bias)
			Qualitative synthesis: 10 effects (range: -.09 to .14), 9 evaluated for significance. 7/9 effects found to be statistically significant, majority adequately powered.	Mod: 7(6)	**Directness**: Indirect (instruments valid to assess teasing experiences, 7/9 effects from cross-sectional reports)
				High: 0(0)	**Consistency**: Consistent (78% of effects found sig mediation via teasing)
			Conclusion: Teasing mediates the relationship		**Precision**: Precise (no meta-analytic confidence interval to examine; 78% of effects in

Goal	Outcome (Question)	#Reports[1] (#Effects)[2] (N)[3]	Summary of Findings	Risk of Bias (sig)[4]	Domain Scores
			between weight status and depression		narrative synthesis were adequately powered) **Overall**: *Moderate* (findings were consistent across adequately powered reports; most reports cross-sectional, with moderate risk of bias ratings)
4		2 (5) (19,664)	*Dieting* **Qualitative synthesis:** 3/5 effects found sig mediation; 2 n.s. (due to lack of sig total effect as per causal steps approach); 4 effects from same report. **Conclusion:** Limited evidence that dieting mediates the relationship between weight status and depression	Low: 4(2) Mod: 1(1) High: 0(0)	**Limitations**: Low (80% effects from same report rated as having a low risk of bias) **Directness**: Indirect (most evidence from same cross-sectional report) **Consistency**: Inconsistent (<70% of effects found sig mediation via dieting, though 4/5 effects from different subsamples in same report) **Precision**: Precise (wide meta-analytic confidence interval only based on 2 effect effects from same report; all effects from sufficiently powered reports) **Overall**: *Low* (Most effects from subsamples within one report; cross-sectional designs)

Note. Sig = statistically significant; n.s. = not statistically significant; GAM = *gender additive model* (Stice & Bearman, 2001)
[1] Number of reports included in quantitative and/or qualitative synthesis for this outcome.
[2] Number of effects included in quantitative and/or qualitative synthesis for this outcome (each effect counted only once).
[3] N = total number of participants from each report included in synthesis for this outcome.
[4] Number of effects at each risk of bias level for this outcome; (sig) = number of significant mediation effects at each risk of bias level.
[5] N includes effects from both Needham & Crosnoe (2005; N = 18,795) and Vaughan & Halpern (2010; N = 10,864), both of which use data from the same larger study (AddHealth). Some participant overlap is possible.
[6] Only one report (Xie et al., 2010; N = 1,155; *n* = 6) conducted formal mediation analysis; Ge and colleagues (2001; N = 3,633; *n* = 8) did not.
[7] Number of reports (and participants) investigating GAM variables only; the full subgroup analysis included all reports (and participants), as all effects were dichotomized into either “GAM” or “non-GAM” variable subgroups.

Research Goal 2: Moderation of Mediated Effects by Gender, Developmental Stage, and Culture

Prior research has shown that the relationship between weight status and depression may be stronger for certain groups of young people. It follows that the pathways through which this relationship manifests may also vary based on certain individual characteristics. The magnitude of mediated effects was predicted to vary based on three factors: gender, developmental stage, and culture. Specifically, the average overall indirect effect was hypothesized to be stronger for females (compared to males), youth with early-onset puberty (compared to youth with normative or late onset puberty), and those who identify as members of cultural groups that endorse a thin ideal (compared to groups that do not endorse a thin ideal). Subgroup analysis was planned to evaluate the moderating role of each of these variables on the average overall indirect effect of all mediators.

Gender. The average overall indirect effect for females was not significantly different from that for males, $p = .13$ (Table 5). This suggests that contrary to our hypothesis, mechanisms through which weight status contributes to depressive symptoms may be similar for males and females. This result may reflect a lack of statistical power (due to the relatively low number of estimates in each subgroup) rather than evidence that gender does not moderate the average indirect effect. The mean indirect effect was small and approached significance for females (M = 0.05; $p = .07$; 95% CI: 0.004 to 0.103; $n = 8$) and was not significant for males (M = 0.01; $p = .57$; 95% CI: -0.023 to 0.039; $n = 7$). Both were characterized by low precision, with wide ranging confidence intervals suggesting heterogeneity across individual study estimates (see Figure 6).

Subgroup analysis of total effects by gender also failed to attain statistical significance (p = 0.79), with non-significant pooled estimates for both females (M = 0.05; p = .32; 95% CI: -0.069 to 0.174; n = 6) and males (M = 0.04; p = .28; 95% CI: -0.041 to 0.115; n = 6). This indicates that, among included reports, the association between weight status and depression was not stronger among females, contrasting previous research findings. Once again, both estimates showed poor precision. Notably, in both indirect and total effects, the between-study variability for females was more than 50% higher than that of males, suggesting consistently greater heterogeneity among females.

Figure 6

Subgroup Analysis by Gender: Average Overall Indirect Effects for Females and Males

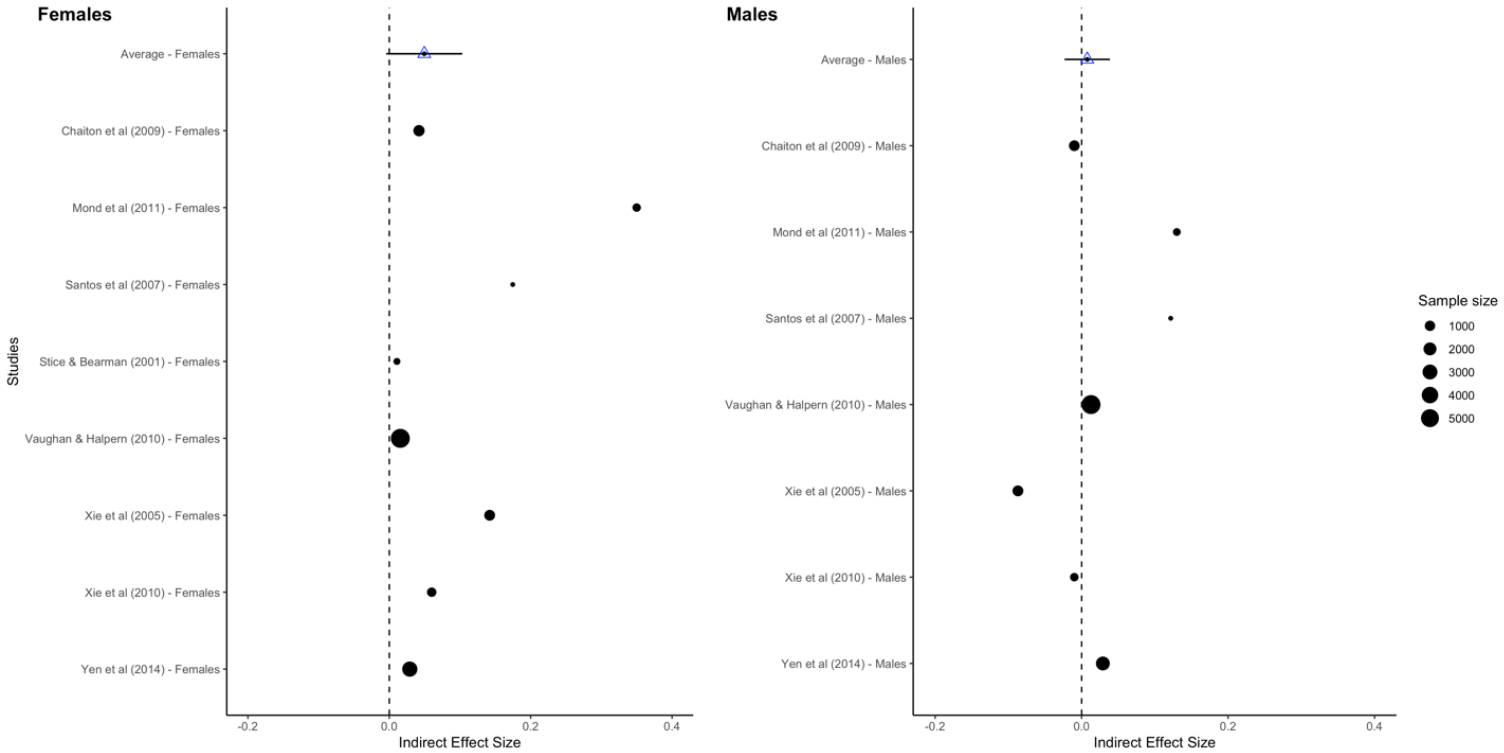
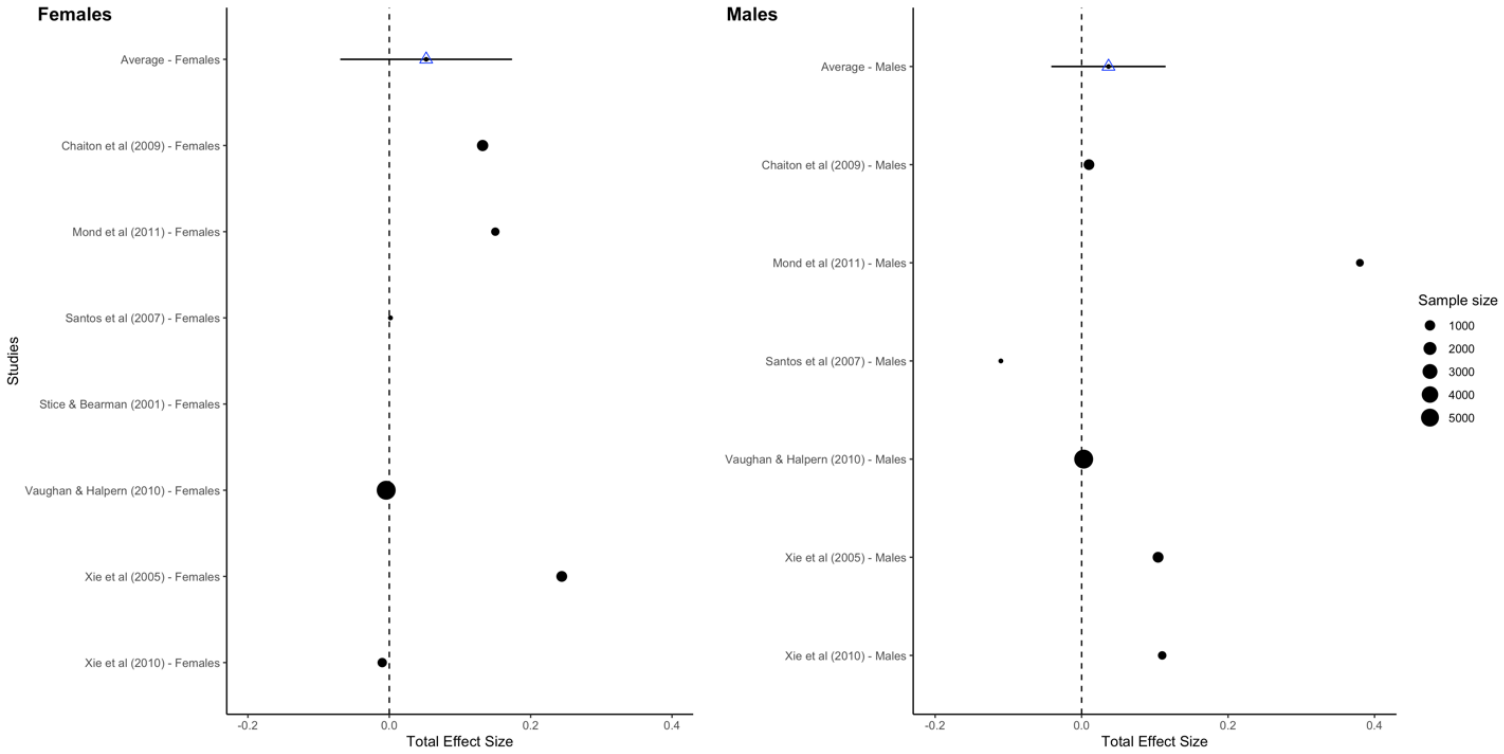


Figure 7

Subgroup Analysis by Gender: Average Overall Total Effects for Females and Males



For qualitative synthesis, eleven reports investigated whether gender moderated proposed mediation pathways, and/or described separate mediation estimates for males and females. None of these provided data for gender identities beyond male and female, nor did any explore how mechanisms may apply differently to transgender or non-binary youth. A total of 18 effects were eligible for inclusion in qualitative synthesis. Contrary to review hypotheses, only five of these effects (28%) demonstrated significant differences between males and females (Chaiton et al., 2009; Mond et al., 2011; Needham & Crosnoe, 2005; Xie et al., 2005, 2010) (see Table 4). Among those that found a gender difference, the direction of effect was generally consistent with our hypothesis, with significant mediation for females but not males in all but one of these reports (late adolescents in (Mond et al., 2011). Reinforcing meta-analytic findings, a larger proportion (13/18 effects) identified no difference in indirect effects between males and females (Gomes et al., 2019; Mond et al., 2011; Pryor et al., 2016; Santos et al., 2007; ter Bogt et al., 2006; Vaughan & Halpern, 2010; Yen et al., 2014). Most of these (n = 9) found that mediators were significant for both males and females, which suggests the mechanisms investigated in these studies have similar magnitudes of effect for girls and boys.

Developmental Stage. Insufficient data was available to allow for separate quantitative subgroup analysis examining the effect of developmental stage on indirect and total effects. Nine reports included a measure of pubertal development (Table 3). These measures ranged from single questions about onset of menarche among females (Allen et al., 2006), to a series of questions regarding the timing and development of physical characteristics associated with puberty (Ge et al., 2001; Xie et al., 2005, 2010), to standardized scales (Pryor et al., 2016; J. K. Thompson et al., 1995), to using age or grade level as a proxy for developmental stage (Chaiton et al., 2009; Mond et al., 2011; Needham & Crosnoe, 2005).

Only three reports (Chaiton et al., 2009; Mond et al., 2011; Needham & Crosnoe, 2005) formally investigated differences in mediation pathways based on stages of pubertal development, obtaining mixed results. Both Chaiton and colleagues (2009) and Mond and colleagues (2011) used age as a rough proxy for pubertal status. Chaiton and colleagues (Chaiton et al., 2009) found no effect of developmental stage on the indirect effect of body dissatisfaction and pressure to be thin, though their sample (ages 13 and 16 years) did not likely include any pre- or early pubertal onset youth for whom mediation might have been magnified. The other two reports described contradicting results: Mond and colleagues (Mond et al., 2011) described significant mediation for late (not early) adolescent males and no moderation by age among females, while Needham and Crosnoe (Needham & Crosnoe, 2005) found significant mediation effects among adolescents in lower grades and non-significant total effects among those in upper grades (prohibiting further mediation analyses).

Culture. While any definition of culture was considered relevant, ethnicity was the most common dimension assessed among the included studies. An insufficient number of reports examined the role of culture or ethnicity as a moderator to allow for adequately powered quantitative subgroup analysis.

Eight reports included ethnicity in their analyses (Table 3). Notably, all of these were conducted in the United States. Of these, six reports (Mond et al., 2011; Needham & Crosnoe, 2005; Santos et al., 2007; Stice & Bearman, 2001; J. K. Thompson et al., 1995; Vaughan & Halpern, 2010) frame ethnicity as a covariate and did not report results separately for participants of different ethnicities. Only two (Ge et al., 2001; Xie et al., 2010) examined ethnicity as a moderator with the explicit intent to understand how one's culture influences their experience of overweight and how this may contribute to depressive symptoms. Ge and colleagues (2001)

found an interaction between gender and ethnicity while controlling for the effect of social class. Perceiving oneself as having 'overweight' was associated with depressed mood among European American boys and girls and Hispanic American girls, but not among Hispanic American boys or African American boys or girls. In fact, perceived weight was negatively associated with depressed mood in African American boys, suggesting a small protective effect of viewing oneself as having overweight in this population. Xie and colleagues (2010) investigated the mediating role of body dissatisfaction, and whether this was moderated by an interaction of gender (male, female) and ethnicity (Asian, Hispanic) or level of acculturation (high, low). They found significant mediation only among Asian girls (not Asian boys, or Hispanic boys or girls) and girls with high levels of acculturation. Taken together, these findings are consistent with the hypothesis that weight status takes on different meanings based both on adolescents' gender and their cultural context, which may translate into different risk for depression for members of different ethnicities.

Conclusions and Strength of the Evidence. Based on these findings, gender did not moderate the mediated relationship between weight status and depression. Gender was the most investigated moderator among included reports. Contrary to the stated hypothesis, both quantitative and qualitative syntheses found no evidence of moderation by gender, indicating that mediation effects identified in the review were not significantly stronger for females compared to males. The strength of this finding was rated as *moderate* based on a moderate risk of bias and generally acceptable statistical power to detect effects across reports (see Table 7). *Insufficient* evidence was available to determine the effect of both developmental stage (which was frequently assessed by age) and culture (which was represented by ethnicity among included reports). The extremely limited findings for the role of developmental stage and culture/ethnicity

highlight a gap in mediation-specific research, and additional research is required to reach a clear conclusion. Together, this lack of evidence supporting a moderating effect of individual characteristics might suggest that it is an interaction of individual characteristics (perhaps an interplay of gender and culture, for example), rather than a single dimension (i.e., gender) that influences the degree to which someone with overweight is susceptible to depression.

Research Goal 3: Mediating Effects of GAM Variables

The GAM was initially developed to explain the higher prevalence of depression among females compared to males during adolescence (Stice & Bearman, 2001). It proposes five intermediary variables that may act as mechanisms through which depression manifests: pressure to be thin, thin-ideal internalization, body dissatisfaction, dieting, and eating disorder symptoms. We sought to apply this model to understanding the link between weight status and depression, by examining whether components of the GAM act as mediators of this relationship and whether these mediating effects differ based on gender, developmental stage, and culture.

Quantitative subgroup analysis was conducted to compare the magnitude of the average indirect effects for variables included in the GAM to those that are not part of the GAM. It was hypothesized that GAM variables would moderate the average overall indirect effect, such that this would be higher in studies of GAM variables compared to non-GAM variables. The search identified a total of 13 reports investigating one or more variables included in the GAM. These yielded 13 separate data points that were eligible for inclusion in meta-analysis subgroup analyses as “GAM” variables, compared to nine data points forming the “non-GAM” variable group. The omnibus test failed to achieve statistical significance ($p = 0.611$, see Table 5), indicating that no meaningful difference was detected between groups. The average indirect effect was small yet significant for GAM reports (M = 0.03; $p = 0.038$; 95% CI: 0.002 to 0.065;

n = 13), suggesting that GAM variables investigated by studies in this review probably played a mediating role in the relationship between weight status and depression (Figure 8). The 95% confidence interval indicated reasonable precision for this estimate (95% CI: 0.002 to 0.065). Notably, only three of the five constructs included in the original GAM were investigated and eligible for inclusion in quantitative synthesis (body dissatisfaction, *n* = 9; pressure to be thin, *n* = 2; dieting, *n* = 2). No effect estimates for the two remaining mediators proposed in the model – thin ideal internalization and eating disorder symptoms – were eligible for inclusion in meta-analysis. Thus, the estimate of the average indirect effect does not represent a true evaluation of the full GAM model.

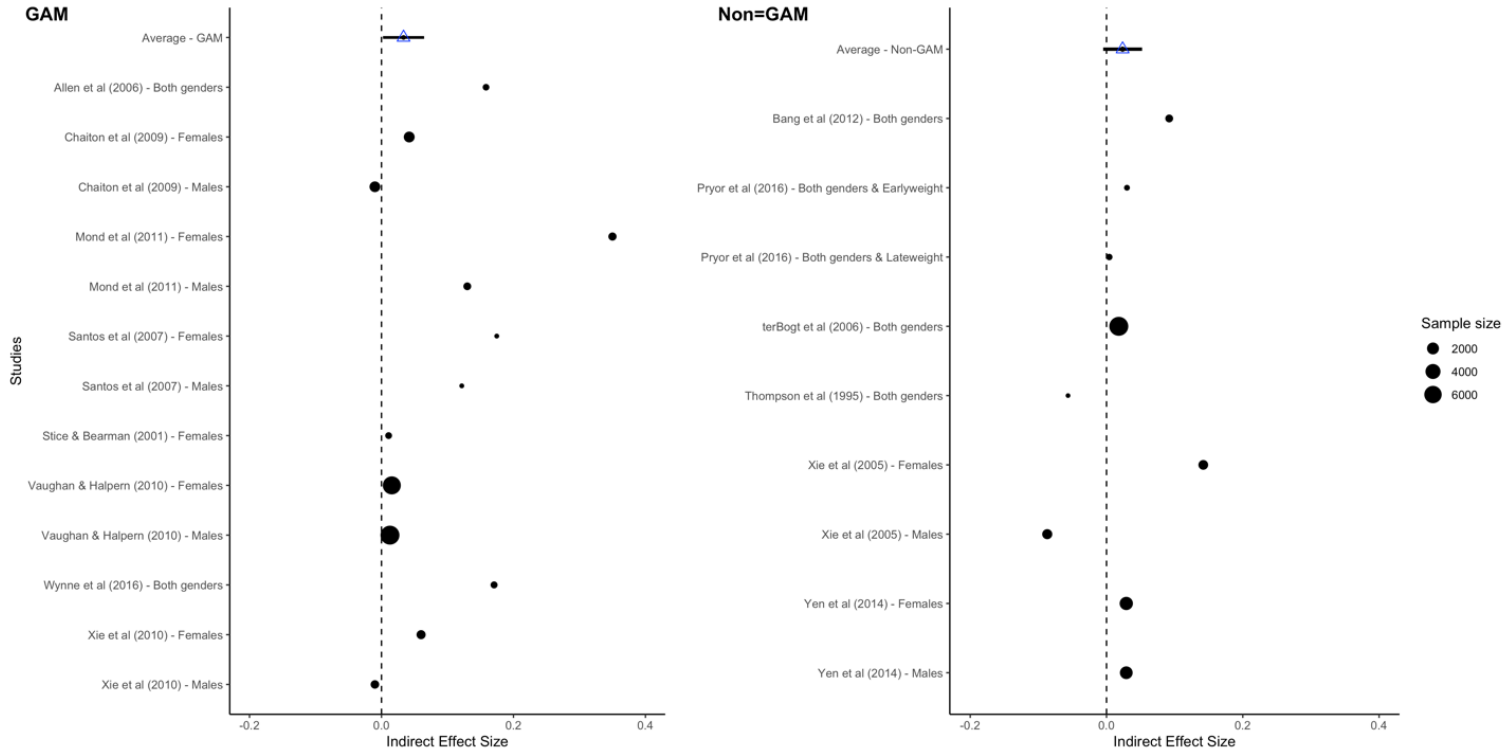
In comparison, the mean indirect effect for non-GAM studies was also small yet failed to achieve statistical significance (M = 0.02; *p* = 0.093; *n* = 9) and was characterized by low precision suggestive of high heterogeneity (95% CI: -0.005 to 0.052) (Figure 8). Eight of the nine included data points represented the mediating effect of teasing or related constructs, with the remaining data point for weight perception (see Table 4). Together, this indicates there is evidence for an average indirect effect of *some* GAM variables, but this effect was not significantly stronger than the average indirect effect of non-GAM mediators.

The omnibus test for mean total effects also failed to achieve statistical significance, suggesting that GAM membership did not moderate total effects either. This confirms the overall relationship between weight status and depression was not significantly stronger in reports investigating GAM variables compared to those investigating non-GAM variables. The mean total effect of weight status on depression in GAM studies was not significant (M = 0.03; *p* = 0.17; 95% CI: -0.015 to 0.074; *n* = 12). The mean total effect for non-GAM studies was

comprised of notably fewer effects (six vs. 12), was moderate in size and found to be statistically significant (M = 0.10; $p = 0.039$; 95% CI: 0.007 to 0.184; $n = 6$).

Figure 8

Subgroup Analysis by Inclusion in the GAM: Average Overall Indirect Effects for GAM and Non-GAM Variables



Two types of reports are included in the qualitative synthesis of GAM findings: those investigating the full model, and those investigating single mediators that are part of the GAM. The search identified four reports which specifically sought to evaluate the validity of the full gender additive model (Chaiton et al., 2009; Santos et al., 2007; Stice & Bearman, 2001; Vaughan & Halpern, 2010). This included the original validation study conducted by Stice and Bearman (2001). Using random regression growth curve analysis, they found support for the role of pressure to be thin, internalization of a thin ideal, body dissatisfaction, dieting, and eating disorder symptoms at predicting the onset of depressive symptoms. Notably, they found no direct effect of body mass on depression, body dissatisfaction, or pressure to be thin (Stice & Bearman, 2001).

The other three reports stated an objective to investigate the GAM but only included a subset of all mediators proposed in the original model. Santos and colleagues (Santos et al., 2007) approximated the model by investigating body dissatisfaction, dieting, and symptoms of bulimia (leaving out pressure to be thin and internalization of a thin ideal). They found improved model fit when the direct effect of BMI on depressive symptoms was included, which suggests the mechanisms only partially accounted for the relationship between these two variables. Vaughan and Halpern (Vaughan & Halpern, 2010) identified significant longitudinal mediation of BMI on depression through the combined effects of weight perception and dieting. Examining an abridged version of the GAM, Chaiton and colleagues (Chaiton et al., 2009) found that body dissatisfaction and pressure to be thin partially mediated the relationship between weight and depression, an effect that was restricted to females only. Finally, a study by Ting and colleagues (Ting et al., 2012) did not specifically cite the GAM but evaluated a model with similar components. They found that the relationship between body weight and depressive symptoms

was partially mediated by a combination of weight perception, weight concern, and dietary restraint. They did not investigate whether these mediation effects differed by gender. Thus, these few studies provide some support for the validity of the original model in the context of the relationship between weight status and depression.

Turning to reports that examined single mediators in the GAM, the most frequently assessed mediator was body dissatisfaction (n = 16), followed by dieting (n = 5), and pressure to be thin (n = 2). The other mediators received considerably less attention. Eating disorder symptoms were evaluated by three reports (Deepthi & Praveen, 2014; Santos et al., 2007; Stice & Bearman, 2001), with only one drawing any conclusions about its specific role (Deepthi & Praveen, 2014). No significance estimates were presented for either pressure to be thin (investigated by two reports: (Chaiton et al., 2009; Stice & Bearman, 2001) or internalization of a thin ideal (Stice & Bearman, 2001). It therefore remains unclear how much of the effect of weight status on depression is mediated by these variables. Of 23 reported effects, only 15 were tested for statistical significance and therefore eligible for consideration in qualitative synthesis (Appendix J). A total of nine mediation effects (60%), for body dissatisfaction n = 5 (Allen et al., 2006; Mond et al., 2011; Pryor et al., 2016; Xie et al., 2010), dieting n = 3 (Needham & Crosnoe, 2005; Ting et al., 2012), and binge eating n = 1 (Deepthi & Praveen, 2014), were found to be significant.

Comparing these findings to those from variables not included in the GAM, 19 individual effects were reported and tested for statistical significance (Bang et al., 2012, n = 1; Gomes et al., 2019, n = 2; Pryor et al., 2016, n = 2; ter Bogt et al., 2006, n = 1; Ting et al., 2012, n = 2; Xie et al., 2005, n = 4; Yen et al., 2014, n = 7). Twelve mediators showed significant effects (63%),

which is similar to the proportion of GAM variables identified as significant. Among these, teasing and bullying-related constructs accounted for nine (75%) of these effects.

GAM and Gender. Gender was expected to moderate the relationships proposed in the model, such that the indirect effect of GAM variables would be significantly stronger for females than for males. Exploratory subgroup analysis was conducted to evaluate this theory-driven hypothesis, as the number of available effects in each subgroup was low (GAM females: $n = 6$, GAM males: $n = 5$, non-GAM females: $n = 2$, non-GAM males: $n = 2$) and therefore underpowered to detect meaningful effects. No significant differences were observed between groups ($p = .492$). None of the mean indirect effects achieved statistical significance, and large confidence intervals for each estimate was indicative of high heterogeneity across groups (see Table 5). Due to the exploratory nature of this analysis, this result is not necessarily evidence that gender has no moderating effect, but rather a reflection of insufficient power to detect true effects should they exist.

Three reports attempting to test the full GAM also investigated the moderating effect of gender. Santos and colleagues (Santos et al., 2007) found no difference in model fit between males and females, indicating that the pathways were equally applicable to both. Vaughan and Halpern (Vaughan & Halpern, 2010) also found significant mediation through their version of the GAM for both males and females. Conversely, Chaiton and colleagues (Chaiton et al., 2009) found that body dissatisfaction and pressure to be thin accounted for 62% of the effect of BMI on depression in females, while these variables failed to achieve statistical significance in males. Despite their original assertion that GAM pathways should apply more strongly to females compared to males, Stice and Bearman (Stice & Bearman, 2001) were unable to evaluate gender differences because their study was conducted with a small, exclusively female sample.

Among reports investigating the effects of single mediators from the GAM, four reports tested the significance of gender differences in mediation, yielding mixed findings. Consistent with hypotheses, Needham and Crosnoe (2005) and Xie and colleagues (2010) found mediation among females but not males (for dieting and body dissatisfaction, respectively). Mond and colleagues (2011) showed mediation through body dissatisfaction among older adolescent boys but not girls, and no gender difference among younger adolescents. Similarly, Pryor found no evidence of moderation by gender participants with either early- or late-onset overweight (Pryor et al., 2016).

GAM and Developmental Stage. Pathways in the GAM were hypothesized to apply most strongly to adolescents experiencing early pubertal development, as their body shape and size would be more deviant from their peer group (Stice & Bearman, 2001). This hypothesis could not be evaluated through meta-analysis as only three reports presented effects separately by age/developmental stage (Chaiton et al., 2009; Mond et al., 2011; Needham & Crosnoe, 2005). These effects were previously presented in qualitative synthesis above (see Research Goal #2), and no additional data specific to GAM was available. As results were conflicting and did not specifically assess developmental stage, they do not provide a clear picture of the applicability of the GAM across developmental stages.

GAM and Culture. Body image constructs in the GAM were predicted to be influenced by the extent to which one's culture promotes a thin ideal. While many dimensions of culture may play a role, ethnicity was most investigated among included reports. Seven reports assessed participants' ethnicity in their investigation of GAM variables. Only one (Xie et al., 2010) specifically examined whether ethnicity (and level of acculturation) influenced the role of GAM mediators in the weight-depression relationship. The authors found that the combination of

gender and cultural contexts that place high value on thinness – in this case, membership in Asian culture and high levels of U.S. acculturation – were associated with significant mediation through body dissatisfaction. Of course, results of one report examining a single mediator from a complex model are insufficient to draw conclusions regarding the role of culture on all GAM model pathways.

Conclusions and Strength of the Evidence. The GAM mediators investigated within the included studies probably had a small yet significant mediating effect on the relationship between weight status and depressive symptoms. Studies examining multi-mediator models found support for some of the mechanisms in the GAM, though only one included all model components. Not all model constructs were evaluated in the included reports, limiting our ability to assess the full effect of the model and may have led to underestimation of mediation effects. The effect of GAM mediators was not significantly better at explaining the obesity-depression relationship than non-GAM variables investigated in this literature. Thus, the strength of the evidence supporting the validity of the GAM as a conceptual model of the link between overweight and depression in youth was rated as *low* (Table 7), and additional evidence is necessary to determine its true effect.

Results of qualitative and exploratory quantitative syntheses found no clear evidence of moderation by gender on the mediated effect of GAM variables. Based on inconsistent findings and underpowered subgroup analysis, this finding was rated as being of *low* strength. The effect of developmental stage on GAM mediation was assessed indirectly (i.e., by participant age), and analyses from only three reports yielded conflicting results. A single report investigated the impact of culture and acculturation on mediation by body dissatisfaction, thus prohibiting

synthesis of results. The strength of evidence was therefore rated as *insufficient*, indicating that additional evidence is required before a conclusion can be reached.

Research Goal 4: Indirect Effects of Mediator Class (Cognitive, Social, Behavioural) and the Role of Individual Mediators

Following a cognitive-behavioural framework, mediators were classified into cognitive, behavioural, and social variables. Quantitative subgroup analysis was conducted to examine the relative importance of each class of mediator (i.e., cognitive, social, and behavioural mediators) on the relationship between weight status and depression. Qualitative synthesis was then conducted to examine the role of individual mediating variables within each class for which at least three effect estimates (originating from two or more different reports) were available.

The average overall indirect effect was not significantly moderated by mediator class (omnibus test $p = .416$, see Table 6), indicating that no one class emerged as a more important mechanism than the others based on the mediators examined in the included studies. Average indirect effects for each mediator class are represented in Figure 4. Because the behavioural subgroup was comprised of only two effect estimates, sensitivity analysis was conducted by running the subgroup analysis comparing only cognitive and social mediator classes. This omnibus also failed to attain statistical significance ($p = .539$), suggesting the relative equivalence of mediation effects of cognitive and social variables investigated in this review.

Mediator class significantly moderated the mean total effect, where the subgroup omnibus test was significant at $p = .001$ (see Table 6). As above, sensitivity analysis was conducted comparing mean total effects from only studies examining cognitive and social mediators, the result of which was not significant ($p = 0.149$). Significant mean total effects were obtained for studies examining cognitive (M = 0.07, $p = .004$; 95% CI: 0.031 to 0.116; $n = 9$) and

social (M = 0.14, p = .012; 95% CI: 0.043 to 0.236; n =7) mediators, but not those examining behavioural mediators (M = -0.00, p = .901; 95% CI: -0.046 to 0.045; n = 2). These means were based on fewer effects than were available for mean indirect effects, as not all reports provided estimates for total effects.

Cognitive Mediators. The average indirect effect of cognitive mediators was small and non-significant (M = 0.05; p = .112; n = 10); it was also characterized by a likely high degree of heterogeneity based on the wide confidence interval (95% CI: -0.013 to 0.105) (Figure 4). This class was comprised almost exclusively of effects of body dissatisfaction (n = 9), apart from one effect estimate for weight perception (ter Bogt et al., 2006). Given that body dissatisfaction represents a disproportionate number of all reported effects, this average cannot be considered to reflect a representative sample of all cognitive mediators.

Cognitive variables were the most frequently examined mediator type across all studies. Among reports that investigated multiple mediator models (k=8), all included at least one cognitive mediator, which suggests these factors play an important role in complex systems. Cognitive mediators investigated in this review were as follows: body dissatisfaction (n = 16), weight perception (n = 10), weight concern (n = 1), general appearance dissatisfaction (n = 1), internalization of a thin ideal (n = 0; only presented as part of full model in Stice & Bearman, 2001), and self-rated health (n = 0; only presented as part of multiple mediator model in Needham & Crosnoe, 2005). Only twelve of these effects were evaluated for statistical significance and therefore eligible for consideration in qualitative synthesis, with eight (67%) finding significant indirect effects [body dissatisfaction (Allen et al., 2006; Mond et al., 2011; Pryor et al., 2016; Xie et al., 2010), weight perception (ter Bogt et al., 2006; Ting et al., 2012), and weight concern: (Ting et al., 2012)]. Four effects showed no evidence of mediation (Mond et

al., 2011; Xie et al., 2010), however two of these (early and late adolescent females, Mond et al., 2011) may be the result of low power due to the exigent requirements of the mediation analyses employed (i.e., use of the causal steps approach which required significant total effects before the significance of the indirect effect could be interpreted).

Body Dissatisfaction. The most investigated mediator in the review was body dissatisfaction, the role of which was assessed in nine reports (Table 3). Sixteen indirect effects of body dissatisfaction were reported; only nine were evaluated for statistical significance. Five effects (56%) were found to be significant (Allen et al., 2006; late adolescent males in Mond et al., 2011; both early- and late-onset overweight groups in Pryor et al., 2016; females in Xie, 2010). Interestingly, in the work by Pryor and colleagues (2016), body dissatisfaction played a significant role both for those who experienced early-onset overweight and those who experienced overweight later in adolescence, suggesting that critical appraisal of one's body can have negative consequences even with shorter exposure to elevated weight. Four effects were reported as non-significant (early adolescent males, and both early and late adolescent females in Mond et al., 2011; males in Xie, 2010). However, two of these failed to reach significance based on conditions of the causal steps approach (i.e., a non-significant total effect of BMI on depression), suggesting these results may reflect inadequate statistical power to detect an effect rather than evidence that body dissatisfaction is not an important mechanism.

The operational definition of body dissatisfaction was relatively consistent across included studies, ranging from "weight and shape concern", to "desire to be thinner", and "body esteem" (Table 3). Remarkably, there was virtually no overlap in measures used to assess the presence of body dissatisfaction – only two reports used the same tool (the Body Esteem Scale, (Mendelson et al., 2001) (Santos et al., 2007; Stice & Bearman, 2001). All reports assessed

weight status using BMI, and the majority (6/9) calculated BMI using objective measurements of height and weight in at least part of their samples (Table 3). This is an important strength, as subjective assessments of weight may be less accurate for those with body image concerns (Elgar et al., 2005; Rasmussen et al., 2007).

Social Mediators. The average indirect effect of social variables also failed to attain statistical significance, exhibiting low precision and notable heterogeneity (M = 0.03; p = .19; 95% CI: -0.016 to 0.068; n = 10). Like the cognitive mediator subgroup, this class was predominantly represented by estimates related to one variable – teasing/bullying (n = 8) – with one study examining the role of pressure to be thin (Chaiton et al., 2009, n = 2). This overrepresentation of teasing limits conclusions that can be drawn regarding the role of all social variables based solely on these findings.

A total of 14 individual effects were reported, representing three constructs: teasing (n = 10), pressure to be thin (n = 2), and perceived availability of social support (n = 2). Eleven of these effects were tested for statistical significance (Bang et al., 2012; Pryor et al., 2016; Xie et al., 2005; Yen et al., 2014), with seven (64%) showing evidence of significant mediation. All significant effects represented the role of teasing among different subgroups of participants. Notably, two of the four data points that failed to achieve statistical significance assessed the role of 'perceived availability of social support' (Xie et al., 2005). This variable was negatively related to excess weight and may have provided a suppression effect that was not detected in mediation (Xie et al., 2005), contributing to non-significant findings.

Teasing. Teasing (also framed as 'victimization') was the most frequently investigated social mediator, included in five reports (Bang et al., 2012; Pryor et al., 2016; J. K. Thompson et al., 1995; Xie et al., 2005; Yen et al., 2014) (see Table 4). Ten estimates of the indirect effect of

teasing were reported, nine of these estimates were evaluated for statistical significance. Teasing significantly mediated the relationship between weight status and depression in most cases (7/9 effects, or 78%) (Bang et al., 2012; Pryor et al., 2016; Xie et al., 2005; Yen et al., 2014). Non-significant effects were found for adolescents with late onset overweight (Pryor et al., 2016) and the male subgroup reported by Xie and colleagues (2005). Null findings in these groups imply that the negative effects of teasing might be more likely among females (Xie et al., 2005) and with longer exposure to elevated weight status (and possibly, more weight-based teasing; (Pryor et al., 2016).

Definitions and measures of teasing varied, reflecting different degrees of severity, frequency, and specificity regarding weight. Three reports employed the use of formal scales (the Korean version of Perception of Teasing Scale, the Physical Appearance Related Teasing Scale, and the Chinese version of School Bullying Experience Questionnaire). All these measures involved asking participants to rate the frequency with which they had previously experienced negative social interactions of varying degrees of severity (e.g., being isolated by peers, being made fun of by other children, being hit or pushed by classmates). Only two measures specifically assessed teasing related to physical appearance (Bang et al., 2012; J. K. Thompson et al., 1995); the others were general in focus and not specifically weight-based. All but one report investigated the role of peers as perpetrators of victimization; Bang and colleagues (2012) examined the role of parental teasing, finding this significantly mediated the relationship between BMI and depression.

Behavioural Mediators. Finally, the average indirect effect of behavioural mediators was very small and approached statistical significance (M = 0.01; p = .063; 95% CI: -0.004 to 0.032, n =2). However, this result should be interpreted with caution as it is comprised of only

two estimates from the same larger study (Vaughan & Halpern, 2010) examining the role of dieting in males and females. Five behavioural mediators were investigated among included reports: dieting (n = 7), eating disorder symptoms (n = 2), bullying perpetration (active, n = 1, passive n = 2), diet quality (n = 1), and physical activity (n = 1). A total of 11 effects were reported, ranging from .003 to .1, all of which were evaluated for statistical significance. Vote counting revealed that six effects (55%) were found to be significant: passive bullying perpetration (Yen et al., 2014), binge eating (Deepthi & Praveen, 2014), and dieting (Needham & Crosnoe, 2005; Ting et al., 2012).

Dieting. Dieting was the most frequently investigated behavioural variable among included reports. Meta-analysis for behavioural variables was comprised solely of two estimates of dieting assessed in the same study (Vaughan & Halpern, 2010), yielding a very small effect that approached statistical significance (M = 0.01; p = .063; 95% CI: -0.004 to 0.032, n =2). A total of five reports examined the role of dieting as a mechanism through which weight status increased the risk for depression. Three of these framed dieting in the context of more complex, multi-mediator models (Santos et al., 2007; Stice & Bearman, 2001; Vaughan & Halpern, 2010), and therefore did not test the significance of the effects of dieting in isolation. Seven indirect effects were tested for statistical significance, with five (71%) finding evidence of mediation through dieting (Needham & Crosnoe, 2005, n = 4; Ting et al., 2012).

Most studies employed the use of validated measures to assess the presence of dieting behaviours: one report used the dieting subscale of the Eating Attitudes Test (Garner et al., 1982), another used only three items from this scale (Table 3). The Dutch Restrained Eating Scale was used by Stice & Bearman (2001) in the context of evaluating the GAM. Vaughan and Halpern (2010) used a dichotomous measure of dieting within the last 7 days, which provided

less detailed information but high test-re-test reliability across longitudinal data points. Sample ages ranged from 12 to 19 years, which is appropriate given that younger children typically have less control over their dietary choices and are therefore less likely to endorse engaging in dieting behaviours.

Conclusions and Strength of the Evidence. No mediator class emerged as having a statistically stronger mediating effect on the relationship between weight status and depressive symptoms than other classes. However, this finding was graded as being of low strength, primarily because a restricted range of mediators were included in each class (Table 7). For cognitive variables, quantitative findings (which demonstrated a small, positive, non-significant effect) contrasted with qualitative findings, though the latter may have been underpowered to detect full effects. Despite a relatively high number of effects, only four cognitive mediators were represented, limiting conclusions that can be made about whether this finding adequately represents the role of all cognitive mediators. Thus, contrary to review expectations, strength of the evidence for the effect of cognitive mediators was rated as *low*. Body dissatisfaction was the most investigated cognitive variable; the evidence for its role as a mediator was rated as *low*, based on a reasonable number of available effects (n = 9).

Similarly, the strength of the evidence in support of social mediators was also rated as *low*. Quantitative synthesis of social variables found a small, non-significant, imprecise average indirect effect, while qualitative synthesis found some evidence (64% significant effects) of mediation. Teasing was the social mediator that received the most consistent support across individual reports; evidence for its was rated as *moderate* strength. This finding is expected to be stable but could change based on additional evidence from high powered longitudinal studies.

Finally, cumulative evidence for the effect of behavioural mediators was also rated as *low*. Although quantitative subgroup analysis was conducted, the estimate was derived from only two effects for the same mediator originating from two subgroups in the same report (Vaughan & Halpern, 2010). Qualitative synthesis findings showed inconsistent significant effects (55%). These were primarily driven by the role of dieting, the evidence for which was limited and therefore rated as being of *low* strength. Confidence in the stability of all these outcomes would be increased with additional evidence conducted using validated measures, with longitudinal designs and mediation approaches that maximize power to detect effects.

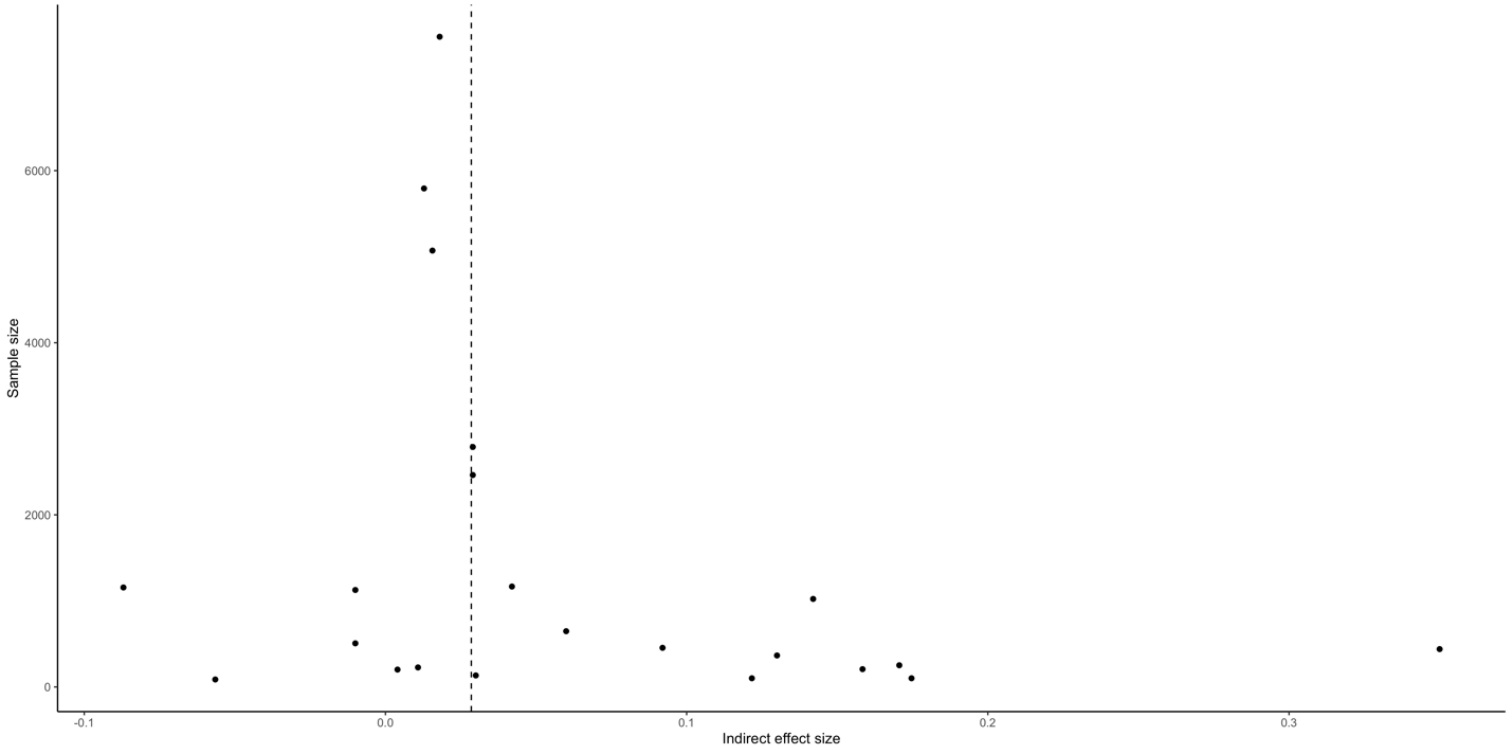
Reporting Bias

Publication bias was assessed using a funnel plot, wherein all indirect effects included in quantitative synthesis were plotted against their corresponding sample sizes (Figure 9).

Examination of the funnel plot reveals one notable outlier. When the shape of the distribution is considered without this outlier, it appears to be only slightly right skewed, as there were more studies that reported positive and larger effects than smaller and/or negative effects. This would indicate a tendency among mediation studies to publish strong effects that may not be reliable because of low sample sizes.

Figure 9

Funnel Plot Representing Possible Reporting Bias of Indirect Effects



Discussion

The aim of this systematic review was to achieve four research goals: 1) to determine whether psychological, social, and behavioural variables mediate the relationship between weights status and depression in children and adolescents, 2) to determine whether mediated effects vary based on gender, developmental stage, and culture, 3) to evaluate whether components of the GAM (Stice & Bearman, 2001) act as mechanisms through which weight status increases the risk of depression, over and above other mediators, 4) to determine whether different mediators have different indirect effects on the relationship between weight status and depression in young people. Nineteen reports employing formal mediation analysis to investigate these constructs were eligible for inclusion in the review. These reports described a total of sixteen different mediators, over half of which were investigated by single studies. Results were primarily from studies employing cross-sectional designs, with a moderate risk of bias. Reports almost exclusively examined depression as a continuous variable; hence, the term 'depression' used herein refers to the presence of depressive symptoms and not to clinical diagnoses. This was the first study of its kind to employ both quantitative meta-analysis and qualitative synthesis to thoroughly review the evidence base for multiple mediators of the relationship between weight and depression in young people, and to apply a structured framework with which to evaluate the strength of synthesis findings. A summary of main synthesis findings is presented in Table 8. The evidence base for each research question is discussed below.

Table 8

Summary of Main Synthesis Findings

Research Goal/Question(s)	Summary of Main Findings	Strength of Evidence (# Effects)
(1) Do psychological, social, and behavioural variables mediate the relationship between weight status and depression in children and adolescents?	• The combination of psychological, social, and behavioural variables investigated by included reports likely mediate the relationship between weight status and depression in young people to a small degree	*Low-Moderate (43)*
(2) Do individual characteristics (gender, developmental stage, and culture) moderate the mediated effects of psychosocial and behavioural variables?	• Contrary to hypothesis, gender did not significantly moderate mediation pathways (only investigated as binary construct) • Insufficient evidence available to evaluate the moderating role of developmental stage or culture.	*Gender: Moderate (22)*
(3) Do variables included in the GAM mediate the relationship between weight status and depression in young people? Are these mediated effects moderated by individual characteristics (gender, developmental stage, culture)?	• Only 3/5 variables in the GAM were investigated • These demonstrated a small, statistically significant mediating effect; however, this was not significantly stronger than the mediating effect of non-GAM variables. • Insufficient evidence that gender, developmental stage, or culture moderate the mediating effects of GAM variables	*Low (29)*
(4) Which class of mediator (i.e., cognitive, social, behavioural) has the strongest average mediating effect? What specific individual psychological, social, and/or behavioural variables significantly mediate this relationship?	• No mediator class had a significantly stronger effect than the others • Cognitive, social, and behavioural variables likely play a mediating role, but available evidence precludes conclusion about the magnitude of this effect • Body dissatisfaction (*low; 9*), teasing (*moderate; 9*), and dieting (*low; 5*) likely play a mediating role (based on qualitative synthesis only)	*Low (22)*

Research Goal 1: The Mediated Relationship Between Weight Status and Depression

Weight status was significantly and positively associated with depressive symptoms among included studies, reinforcing previous evidence establishing a relationship between obesity and depression in young people (Mannan et al., 2016; Quek et al., 2017; Sutaria et al., 2019) and bolstering calls to better understand the processes underlying this link. The significant average indirect effect of all mediators in the review confirmed the hypothesis that psychological, social, and behavioural factors act as mechanisms through which excess weight increases the risk of depression in this population. The average overall indirect effect of all mediators accounted for approximately half of the average overall total effect of weight status on depressive symptoms identified in this review. This is consistent with related qualitative review findings in adults (Preiss et al., 2013) and adolescents (Russell-Mayhew et al., 2012; Sikorski et al., 2015). This finding is important because unlike genetic or biological mechanisms, these factors are more likely to be amenable to change, and thus may serve as targets for intervention.

Research Goal 2: Moderators of Mediated Effects: The Role of Gender, Developmental Stage, and Culture

Mechanisms underlying the weight-depression relationship may not apply equally to everyone. Certain individual characteristics may influence the magnitude of mediation pathways, such that some people experience greater effects than others. Subgroup analysis was conducted to determine whether the magnitude of the average indirect effect differed based on participant gender, developmental stage (age), and culture (ethnicity).

Previous research has demonstrated a stronger link between obesity and depression among females compared to males (Mühlig et al., 2016a; Quek et al., 2017; Sutaria et al., 2019). Accordingly, it was hypothesized that gender would moderate both the average total and indirect

effects, such that there would be a stronger association between weight and depression among females compared to males, and that the difference in the magnitude of effect could be attributable to males and females experiencing different degrees of mediating variables. These hypotheses were not supported by results of this review, which demonstrated that many of the investigated mediators applied similarly to boys and girls. This echoes findings in adult (Preiss et al., 2013) and adolescent (Rawana et al., 2010) samples which also failed to identify significant moderation of mediated effects by gender.

Girls are bombarded from an early age with implicit and explicit messages reinforcing the sociocultural thin ideal for women (Sicilia et al., 2023; Vuong et al., 2021), a value system which becomes internalized with repeated exposure (Jiotsa et al., 2021; E. Robinson, 2017). However, there is often an assumption that this societal pressure is not as strong among males (E. Robinson, 2017), and is thus less likely to lead to negative mental health outcomes. These results challenge this assumption. Boys are increasingly exposed to stigma and social pressure to attain unrealistic physical ideals (i.e., of muscularity and/or thinness) from peers and social media (Couch et al., 2016; Helfert & Warschburger, 2013). Rates of severe obesity in particular are higher in boys than girls, notably in middle childhood (Carsley et al., 2019; Spinelli et al., 2019). This group, whose body shape does not conform to these ideals, may be particularly susceptible to this messaging, contributing to a decreasing gender gap in the onset of depressive symptoms in those with the highest weight status. Thus, the lack of moderation by gender suggests that models developed to explain these pathways for females may also apply to males (Karazsia et al., 2017).

There are two important points to consider when interpreting this finding. First, is the crucial distinction between actual weight (i.e., the number on the scale), and how body size is

perceived. Whether one self-identifies as having overweight may have a greater influence on mental health outcomes than objective weight status (Haynes et al., 2019; Roberts & Duong, 2013; E. Robinson et al., 2020; Zhao et al., 2012), and existing evidence points to a gender difference in the accuracy of weight perception (Roberts & Duong, 2013; Schiefelbein et al., 2012; ter Bogt et al., 2006). Females are more likely than males to overestimate their weight, particularly if their actual weight falls in the normal range (Bhurtun & Jeewon, 2013; Jankauskiene & Baceviciene, 2019; Martin et al., 2009). This may be a product, in part, of exposure to images in media that present underweight female forms as normative, leading female adolescents in particular to inaccurately evaluate what is 'normal' (E. Robinson, 2017). This would influence review findings regarding mediation effects in a meaningful way: if perception of overweight is driving the effect of weight on depression, and females' perception of overweight tends to be high regardless of BMI, we would expect to observe high heterogeneity of effects for females. This was reflected in the current findings, with females demonstrating higher heterogeneity compared to males. The difference between indirect effects for males and females would therefore be reduced.

The second consideration pertains to methods used to measure weight status. Individual studies included in the review consistently employed the use of BMI (alone or in combination with other methods) to assess participants' weight status. While this is the most common method for measuring weight status in research and practice, it provides no information about body composition and may not be sensitive to the nature of males' relationships with their bodies. Traditionally, the ideal for males is one of muscularity; this is not adequately captured using a BMI metric, which does not differentiate between lean (muscle) mass (typically viewed as socially desirable) and fat (typically viewed as socially undesirable). BMI therefore does not

adequately capture the body-related factors that are likely to be most associated with depression among males (Blashill & Wilhelm, 2014), as high or very low BMI could be perceived positively or negatively in boys. This would lead to notable heterogeneity of effects (as observed in this review) and attenuate the relationship between weight status (as measured by BMI) and depression compared to what it might be using methods sensitive to body composition. An insufficient number of studies used alternate methods of measuring weight status (such as waist circumference or dual-energy X-ray absorptiometry) to allow sensitivity analysis of effects across methods.

Hypotheses related to the moderating effects of developmental stage and culture could not be properly tested due to insufficient available data. Age was used as a proxy for developmental stage in three studies, yielding inconclusive results regarding early development. Regarding the role of culture, it was predicted that cultural groups subscribing to a thin ideal would exhibit stronger indirect effects of weight status on depression than groups that traditionally embrace broader definitions of beauty. Although several studies assessed participants' ethnicity, only two framed this as a measure of culture likely to impact mediation pathways. Too few effect estimates were available from which to conduct meaningful evidence synthesis, though limited data suggests a possible interaction effect of gender and ethnicity.

Research Goal 3: The 'Gender Additive Model' of Depression and the Relationship Between Weight Status and Depressive Symptoms in Children and Adolescents

Stice and Bearman (2001) initially proposed the gender additive model of depression (GAM) to explain the increased prevalence of depression among females which manifests during adolescence. Borrowing from literature in the field of eating disorders (Stice, 1994; Stice & Agras, 1998), it proposes that increased risk of depression in adolescent females is conferred

through body image and eating disturbances, specifically pressure to be thin, thin-ideal internalization, body dissatisfaction, dieting, and eating disorder symptoms. Given that obesity has been consistently linked to both body image concerns (Voelker et al., 2015) and eating disturbances (Chaves et al., 2023), we posited that the GAM variables could explain how obesity contributes to an increased risk of depression, particularly for females. This review evaluated the following hypotheses: (a) variables included in the GAM will act as significant mediators through which weight status contributed to depression, (b) GAM variables will have a stronger mediating effect than variables not included in the GAM, and (c) the average mediating effect of GAM variables will be stronger for females than males (d) the average mediating effect of GAM variables will be stronger for those experiencing early onset puberty compared to those experiencing normative or late pubertal onset, and (e) the average mediating effect of GAM variables will be stronger for individuals belonging to a cultural group that places high value on thinness compared to individuals from groups that do not endorse a thin ideal.

Due to an insufficient number of reported estimates to allow adequately powered subgroup analysis, it was not possible to evaluate hypotheses regarding the moderating effect of gender, developmental stage, or culture on the mediating effect of GAM variables. Thus, results could not support or refute a basic premise of the GAM that model pathways apply more strongly to females than to males in the context of the obesity-depression relationship.

Results of both qualitative and quantitative synthesis supported the hypothesis that some GAM variables significantly mediate the relationship between weight status and depression, though the effects are small. Three of the five variables proposed in the GAM (body dissatisfaction, pressure to be thin, and dieting) were investigated among included studies, contributing to the small, statistically significant indirect effect. The two GAM variables not

captured by this review – thin ideal internalization and eating disorder symptoms – have been linked in previous work to both weight status and depression (Boone et al., 2011; Flament et al., 2012; Jebeile et al., 2021; B. Kenny et al., 2022; K. A. Thompson et al., 2017). Thus, the small, statistically significant effect we observed may have been larger if the absent GAM variables had been represented in the literature. This remains to be investigated in the context of mediation studies.

The basic structure of the GAM – body image concerns and eating disturbances – is supported by existing research. Young people with obesity are more likely to have body image concerns than their normal weight peers (Voelker et al., 2015), and these concerns are predictive of both disordered eating (Sharpe, Griffiths, et al., 2018; Vander Wal et al., 2008) and depressive symptom onset (Murray et al., 2018; Sharpe, Patalay, et al., 2018). These associations are echoed by four studies in the current review that attempted to test the mediating effects of the full GAM (i.e., multiple mediators acting together) on the weight-depression relationship. Apart from the original validation study (Stice & Bearman, 2001), which failed to identify an effect of BMI (likely due, in part, due to a small, exclusively female sample), all others found support for the combined role of body image and eating disturbances in mediating the relationship between BMI and depressive symptoms. Together, these findings support the general framework of the GAM.

Contrary to our hypothesis, GAM membership did not moderate the average indirect effect, indicating that despite achieving statistical significance, GAM variables do not necessarily play a stronger mediating role than non-GAM variables. Again, not all GAM variables were represented in the average indirect effect; it is possible that had all mediators been included, the effect may have been stronger and may have yielded a significant difference. The average indirect effect of variables not included in the model failed to achieve statistical significance,

likely reflective of a high degree of heterogeneity and a smaller sample of estimates than was available for GAM variables. Examination of non-GAM models reveals this indirect effect was driven largely by effects relating to external factors – specifically different types of social influence, which are less represented in the GAM. 'Pressure to be thin', which describes perceived sociocultural pressure from families, peers, partners and institutions to achieve and adopt a thin ideal (Stice et al., 1996) is the only GAM mediator specifically examining social influences on the weight-depression relationship and was only investigated by one report in the current review. The lack of moderation effect of GAM membership could suggest that social factors falling outside of this model play an important mediating role. The differences on the average indirect effect based on mediator class (i.e., cognitive, behavioural, and social variables) are further explored below.

Research Goal 4: Effect of Mediator Class and Individual Mediators on the Relationship Between Weight and Depression?

Understanding the specific mechanisms underlying the link between weight and depression can point to targets for treatment and prevention. Approaching this process from a cognitive behavioural lens, both problematic thoughts about one's weight and negative behaviour patterns contribute to the development and maintenance of depressive symptoms and may therefore act as levers through which to affect change in these symptoms. Further, the experience of different external social pressures provides the context through which problematic thoughts may manifest. This review endeavoured to determine which of these components plays the strongest role in mediating the obesity-depression relationship, to direct screening and prevention efforts where they might have greatest effect. This was accomplished first through subgroup analysis to examine the relative difference in indirect effects across mediator class (i.e.,

cognitive, social, and behavioural mediators), and then by qualitatively examining the role of individual mediating variables for which at least three effect estimates (originating from two or more different reports) were available.

Meta-analytic findings from this review did not identify any significant differences in mediating effects across different mediator classes. Cognitive, social, and behavioural variables showed similar indirect effects on the relationship between weight status and depression, supporting a role for all components of this framework as potential targets for intervention and prevention efforts. Separate effects for each class were small and failed to attain statistical significance; this was likely a result of a small number of estimates in each class resulting in subgroup analysis that may have been underpowered to detect effects.

Cognitive Mediators

Cognitive theories of depression emphasize the role of negative thought patterns in promoting and maintaining negative mood, emotion dysregulation, and other characteristic features of depression (Gotlib & Joormann, 2010). Applied in the context of obesity, how a person perceives and interprets their weight status is what confers increased risk of developing depression, over and above the objective number on a scale. Thus, it was hypothesized that cognitive variables would significantly mediate the relationship between weight status and depression. This hypothesis was not supported by quantitative synthesis findings. Cognitive variables had a small average indirect effect which failed to attain statistical significance, though qualitative synthesis found somewhat greater support with just under 70% of estimates demonstrating significant mediation. That the role of cognitive mediators was not supported more strongly by the available evidence may reflect the limited range of variables investigated among included studies. Only three cognitive variables – body dissatisfaction, weight perception,

and weight concern – were available for synthesis, with the body dissatisfaction representing the bulk of included estimates. Other cognitive constructs possibly related to obesity and depression were notably absent from included reports. For example, beliefs that obesity is a character flaw, or that obesity will lead to social rejection, align with the negative cognitive triad (i.e., negatively biased views of oneself, the world, and the future) characteristic of thinking patterns in depression (Beck, 1979). Should these and other cognitive factors have been included, a stronger mediation effect may have been observed.

Body dissatisfaction was by far the most frequently investigated cognitive mediator in the review. Qualitative synthesis showed a positive effect in slightly more than half of included reports, consistent with previous work linking body dissatisfaction to both obesity and depression (Bornioli et al., 2021; Goldfield et al., 2010; Moradi et al., 2022; Morken et al., 2019; Soares Filho et al., 2020). The strength of this evidence was graded as *low* due to imprecision of effects and inconsistent findings across participant subgroups. This may have been a result of two factors. First, although included studies defined body dissatisfaction in similar terms, there was no overlap in instruments used to assess it, which may have contributed to heterogeneity of effects. Second, although typically more prevalent among those with obesity, body dissatisfaction is common among individuals of all body types (Wang et al., 2019; Weinberger et al., 2016), a trend that is increasing (Gonzaga et al., 2023). Body image concerns are particularly prevalent during adolescence, when the combination of age-related physical development, identity formation, increased exposure to sociocultural appearance ideals, and increased emphasis on peer and social acceptance intersect (Voelker et al., 2015). Thus, the correlation between weight status and body dissatisfaction may have been weak among included studies, resulting in lower-than-expected mediation effects.

Social Mediators

Negative cognitions about weight are unlikely to manifest spontaneously; implicit and explicit social messages play a crucial role in forming personal beliefs about the value and acceptance of larger bodies, and in initiating the psychological distress that can accompany these beliefs. For example, in an extension of minority stress paradigm (Meyer, 2003), Sikorski and colleagues (2015) proposed that because individuals with obesity form a socially stigmatized group, the social bias and discrimination they experience as a result leads to specific risk factors for psychopathology, including internalized stigma and body dissatisfaction. Further, people in overweight bodies commonly experience weight bias and discrimination (Puhl & Heuer, 2009), which often begins in childhood (Puhl & Lessard, 2020). Social variables were therefore hypothesized to have a significant mediating effect on the relationship between weight status and depression, such that people in overweight bodies experience unique social pressures that contribute to depressive symptoms over time.

Quantitative subgroup analysis revealed a small, statistically non-significant effect that was relatively imprecise, and qualitative synthesis found some support for social variables. The most frequently investigated social variable was teasing.

Weight bias is pervasive in multiple social contexts, particularly in Western cultures where great value is placed on physical appearance and thinness is considered the ideal form. Among children and youth, weight stigma is most experienced in the form of weight-based teasing or bullying (Puhl & Lessard, 2020). Weight is by far the most common reason that youth are teased (Puhl et al., 2016), and while weight-based teasing is prevalent among adolescents generally, young people with overweight and obesity are significantly more likely to experience victimization than average-weight peers (Goldfield et al., 2010; Hooper et al., 2021; Tan et al.,

2022). The current review found that teasing significantly mediated the relationship between weight status and depression in almost all studies where statistical significance was reported. This is consistent with existing research that found weight-related teasing to be predictive of both short- and long-term depression (Szwimer et al., 2020), as well as binge eating, poor body image, lower physical activity, and unhealthy weight control practices (G. Chen et al., 2022; Puhl et al., 2017; Puhl & Lessard, 2020). Risk of these negative outcomes may be differentially impacted by the availability and quality of parental support (Himmelstein & Puhl, 2019), as well as adolescents' ability to use effective coping strategies to manage emotions related to victimization experiences (Walsh et al., 2021).

Weight-based teasing can be perpetrated by family members, friends, peers, and even teachers (Nutter et al., 2021; Puhl & Latner, 2007), with teasing from multiple sources likely leading to worse outcomes (Eisenberg et al., 2003). In the current review, included reports focused primarily on the role of peers as sources of teasing. Given that peers commonly take on a more influential role as youth progress through the teen years (Laursen & Veenstra, 2021), teasing and rejection from peers may have a more detrimental effect on adolescents compared to younger children (S. Robinson, 2006).

Beyond the effects of teasing, the mediation effects of social connections were only marginally investigated by studies included in this review. A substantial body of evidence across decades has consistently (and increasingly) shown that children with overweight are often socially marginalized (Strauss & Pollack, 2003), receive fewer friendship nominations and more 'dislike' nominations (De La Haye et al., 2017), and are less likely to be selected as friends than children with physical disabilities and facial disfigurement (Latner & Stunkard, 2003; Richardson et al., 1961). Further, existing evidence suggests that social connections may mediate

and moderate the effects of body shame on depression in young people (Brewis & Bruening, 2018). Only one report included in this review (Xie et al., 2005) examined the role of perceived availability of social support and found no significant mediation effects. Again, these insufficient findings indicate an area that is understudied in terms of mediation pathways, rather than evidence of no effect.

Behavioural Mediators

Cognitive behavioural theory posits that behaviours have a reciprocal effect on thoughts and emotions, and play a pivotal role in maintaining or changing psychological states (Westbrook et al., 2011). Behavioural strategies aimed at changing eating patterns and physical activity are frequently used in the context of obesity treatment (Dobson et al., 2008; Kamath et al., 2008; Oud et al., 2019), and behavioural activation is often a component of CBT treatment protocols for depression (Cuijpers et al., 2023). This review investigated the role of behavioural mediators of the relationship between weight and depression in kids, to determine if young people with excess weight are likely to engage behaviours that increase their risk of developing depressive symptoms. Review findings are based largely on qualitative data, as meta-analytic subgroup analysis, which found a small effect that approached statistical significance, was comprised of only two estimates of the same mediator (dieting). Low strength qualitative evidence suggested a significant mediating effect for three of the five mediators investigated (dieting, binge eating, and passive bullying perpetration).

The most frequently examined behavioural mediator among included studies was dieting. “Dieting” is a broad term whose definition varies widely, but generally refers to an “intentional, often temporary, change in eating to achieve weight loss” (Whyte et al., 2004). Examples include caloric restriction, skipping meals, avoidance of specific foods, or the use of diet pills. A positive

indirect effect of dieting on the relationship between weight and depression was identified based on seven reported estimates. This aligns with data indicating that individuals with overweight and obesity are more likely to engage in dieting, dysregulated eating and compensatory strategies (e.g., fasting, vomiting, taking diet aids) than those with normal weight (Chin et al., 2018; Loth et al., 2014; Mendes et al., 2014). It also reflects prior findings that adolescents who report dieting to lose weight demonstrate increased depressive symptoms (Crow et al., 2006; Hinchliff et al., 2016; Solmi et al., 2021). However, the evidence base was graded as being of low strength, primarily because of varying results across different participant subgroups from cross-sectional studies, echoing variable findings among adult samples in previous work (Preiss et al., 2013; Rawana et al., 2010).

That the effect of dieting was not stronger or more consistent may be a product of how these behaviours were assessed in included studies. Reports investigating the role of dieting in the context of more complex, multi-mediator models did not report the significance of effects of dieting separately and therefore could not be included in the summary of its overall effect, leading to possible underestimation. Further, although it is more common among youth with overweight or obesity, dieting is increasingly prevalent among teens of all body types (C. Berg & Larsson, 2020; Brown et al., 2019; Solmi et al., 2021). When the presence of dieting behaviours is assessed dichotomously, or when measures fail to evaluate dieting frequency, intensity or duration, variability is not captured and the power to detect mediation effects is reduced. In this case, the mere presence or absence of *any* dieting behaviours may not be effectively predicted by weight status (i.e., small magnitude of path *a*, see Figure 2), reducing the likelihood of detecting any statistical mediation. Three of five included reports used simple, dichotomous measures to assess the presence of dieting, which may have reduced the power to detect mediation effects.

The mediating effect of dieting on the obesity-depression relationship likely functions through *failed* attempts at weight loss through dieting behaviours. Markowitz (Markowitz et al., 2008) explains that, fitting with a cognitive behavioural framework, failed attempts at weight loss through dieting may activate schemas related to weight-based self-worth, propagating depressive symptoms. This aligns with the role of dieting presented in the GAM, which posits that dieting – specifically the emotional distress associated with failed attempts at weight reduction, along with negative mood that accompanies caloric restriction – contributes to the development of depression (Stice & Bearman, 2001). Dieting has reliably been shown to be an ineffective means through which to achieve long-term weight loss (Neumark-Sztainer et al., 2007) and is associated with both long-term weight gain (Field et al., 2003) and negative psychological consequences (Crow et al., 2006; Whyte et al., 2004). It may therefore perpetuate the relationship in a cyclical fashion, such that failed dieting attempts increase the risk of depression and exacerbate the presence of overweight.

Clinical Implications

This evidence synthesis supports the existence of a link between obesity and depression in children and youth. Clinically, this suggests that healthcare providers treating young people with excess weight should consider screening for the presence of depressive symptoms using valid, age-appropriate measures, even if this is not initially apparent. As depressive symptoms can interfere with engagement in health promoting behaviours (May et al., 2024) and impact adherence to treatment protocols (Jensen et al., 2012), identifying the presence of comorbid obesity and depression should impact treatment planning by addressing mental health needs and change readiness before implementing major lifestyle changes (Brennan et al., 2008; Jelalian et al., 2019; Kang & Kwack, 2020).

Review findings confirmed that psychological, social, and behavioural factors act as mechanisms through which some of the risk of depression is conferred. These factors are likely amenable to change and thus may serve as targets for treatment (among young people already struggling with depressive symptoms) and secondary prevention (among young people in larger bodies who are not yet experiencing depressive symptoms). These results imply that even in the absence of obvious depressive symptomatology, attention should be paid to factors which may over time increase the risk of the development of depression. Early identification of a patient's risk factors could prevent the onset of comorbidity and improve mental health outcomes in this vulnerable group.

We hypothesized that these risk factors would differentially affect individuals based on their gender, developmental stage, and culture. Contrary to our hypotheses, gender did not moderate mediation pathways among the included studies. Many mediators captured in this review were found to be equally relevant to males and females, and the heterogeneity observed particularly across effects for females suggests that they should not be considered a monolithic group. This highlights the need for health care providers and educators to self-assess for gender bias in relation to weight. For example, providers should be mindful not to assume that boys are less distressed by body image issues, or that all females with excess weight endorse a thin ideal. Individualized care plans, considering risk factors relevant to the patient, are the recommended practice (Hampl et al., 2023b) and are substantiated by these findings.

We proposed that variables included in the GAM would mediate the relationship between weight status and depression, and that if the model were to be supported by available evidence, could be used to guide conceptualization and treatment targets. Meta-analysis findings showed a small, significant effect for three of the five GAM variables, indicating that assessment should

include evaluating the presence of body dissatisfaction, pressure to be thin, and dieting in both boys and girls. The mediating role of GAM variables was not, however, significantly different than that of non-GAM variables. Clinically, this suggests that while the pathways in the GAM should be considered when providing care, they may not tell the whole story, and other relevant factors should also be investigated.

In subgroup analysis by mediator class, cognitive, behavioural, and social factors had similar effects on the development of depression in children and youth with overweight and obesity, indicating that all three should be assessed and addressed in the context of providing care. Consistent with a cognitive behavioural framework, a person-centred approach to treatment should be adopted which targets both negative weight-related thought patterns and maladaptive behaviours, as well as aspects of a young person's social context. Our evidence synthesis revealed that the cognitive, social, and behavioural variables that are most likely to impact depression are body dissatisfaction, weight-based teasing, and dieting, respectfully.

Experiencing excess weight can lead young people to view their bodies negatively, which over time may contribute to feelings of low mood and other depressive symptoms. However, it is important for healthcare providers to recognize that not all young people presenting with overweight are discontent with their bodies. Increasingly, many youths are embracing trends toward body positivity (Mazzeo et al., 2024; Rodgers et al., 2014) and/or body functionality (Alleva & Tylka, 2021) – where emphasis is placed on acceptance of all body types and celebrating what bodies can do rather than how they look – and pushing back against messages that promote weight-based shame. Thus, healthcare providers should incorporate screening for facets of body dissatisfaction (rather than simply assuming its presence) into the assessment process. Care should be taken to do this gently and respectfully, using assessment measures

validated in community and clinical samples (for example, the Weight and Shape Concerns subscales of the Eating Disorders Examination Questionnaire, (see Kling et al., 2019 for review of measures). Consideration should be given to possible gender differences in body dissatisfaction; for example, as traditional ideals suggest male-identifying patients may be more driven towards muscularity (Dondzilo et al., 2019), a measure that captures this construct may be indicated (e.g., Drive for Muscularity Scale; McCreary & Sasse, 2002). If identified, body image concerns could be addressed using CBT strategies (Lewis-Smith et al., 2019), for example by addressing cognitive distortions regarding one's weight, recurrent thoughts about appearance, or biased social comparisons (Yokoyama et al., 2022).

A common misperception, even present among some educators and healthcare providers, is that increasing a person's awareness of their overweight status and dissatisfaction with their body may motivate them to lose weight (E. Robinson et al., 2020; H. R. Thompson & Madsen, 2017). In fact, the opposite is true, and both perception of overweight (E. Robinson et al., 2020) and body dissatisfaction may instead be associated with shame and harmful lifestyle choices (Alberga et al., 2016; Bacon & Aphramor, 2011). This can also be fostered unintentionally: when a young person presents for weight-related treatment, setting treatment goals focused exclusively on reducing weight can inadvertently reinforce beliefs that their body is unacceptable. Alternatively, programs that adopt a "health at every size" (HAES; Bacon & Aphramor, 2011) or similar weight-inclusive approaches (see F. Berg et al., 2003) move away from weight-based lifestyle modification and toward weight-neutral outcomes focused on body acceptance and overall health. Evidence shows that these types of programs can challenge weight-based stigma and are more likely to lead to positive long term health benefits (Hunger et al., 2020; Tylka et al., 2014; Ulian et al., 2018).

One of the more robust findings of this review highlights the role of weight-based teasing in the development of depressive symptoms among children and youth with excess weight. This may take the form of explicit verbal and physical aggression from peers, or more subtle experiences of stigma including social rejection or negative comments about weight from family members, friends, educators, and even medical professionals (Puhl & Heuer, 2009; Puhl & Lessard, 2020). This has several implications for care. At the individual level, when young people are presenting for obesity-related treatment, care should be taken to evaluate whether the patient is the current or past victim of teasing, as well as the source, extent, frequency of the teasing experienced, and its emotional impact. Services could be directed to mitigate the effects of these experiences, such as bolstering family support (Darling et al., 2023). Guidelines for the treatment of obesity in children and adolescents recommend family-based interventions (Hampl et al., 2023b), which provides an opportunity to evaluate and address ways that family dynamics foster teasing and reinforce harmful negative beliefs about weight. Addressing the source of teasing can be difficult but is equally important to effect systemic change for this vulnerable population (Hampl et al., 2023b). Weight-based teasing in childhood is a manifestation of broader weight bias and stigma which exists in multiple social contexts. From a policy perspective, these findings support the calls to action to address weight stigma that is perpetuated through public health campaigns (Alberga et al., 2016) and school-based curricula (Ireland et al., 2023; Tingle et al., 2023) that paradoxically teach that thinness is representative of good health. Further, school-based anti-bullying programs should be implemented with specific focus on weight bias, including awareness-raising with educators, parental involvement, and peer-led support (Aimé et al., 2017; Haines et al., 2006; Lessard & Puhl, 2021; Puhl et al., 2013).

Finally, dieting was also identified as playing a small mediating role in the obesity-depression link. Given its prevalence particularly during adolescence, dysfunctional eating patterns should be monitored as part of primary care wellness checks and in those presenting for weight-related care. Young people may not be forthcoming about these behaviours which can be a source of shame (Iannaccone et al., 2016), and it is important for providers to take a non-judgmental stance and to use supplementary information (e.g., comparison of growth charts in the event of unexpectedly rapid decline in body weight; (Hampl et al., 2023b). Dieting can be framed as a behaviour that serves to manage emotional distress related to perceived overweight, and is often an indicator of other unhealthy behaviours and depressed mood in adolescents (Crow et al., 2006; Whyte et al., 2004). Further, youth may engage in dieting for a variety of reasons that extend beyond weight, including aesthetics, low self-esteem, improved health, avoidance of bullying, family pressure, or as part of prodromal eating disorders (Whyte et al., 2004). Clinicians should therefore seek to understand the motivation underlying dieting behaviours, and to target these by building skills to manage these in more adaptive ways.

Limitations and Future Directions

Despite the information gleaned from this review, some important constructs remain underexplored. First, several variables shown to be associated with both obesity and depression were not represented among included studies. Sleep, for example, has been reciprocally linked to obesity in adolescents (Chaput et al., 2017), and plays a crucial role in their cognitive, emotional, and physical development (Lokhandwala & Spencer, 2022). It has also repeatedly been shown to impact mood (Konjarski et al., 2018; Peterson & Benca, 2008; Watling et al., 2017); in fact, impaired sleep patterns are a considered a symptom of depression (APA 2013). It was surprising, then, that no reports investigated this variable as a potential mediator of the relationship between

weight status and depressive symptoms. Further, physical activity – and relatedly, sedentary behaviour – was notably absent from mediation-based studies included in the review, with only one report investigating its effects (Gomes et al., 2019). Given that young people with excess weight are less likely to engage in physical activity than their normal weight peers (often because of shame or social exclusion) (Hills et al., 2011), and that physical activity has clear links to mood (Bursnall, 2014), its mediating role is understudied based on the current findings. Finally, social media use and screen time were not investigated by any included reports. Excessive social media use has been linked to depression in adolescents (Blanchard et al., 2023; Keles et al., 2020), and youth who engage in problematic use are more likely to have overweight or obesity (Oduro et al., 2023). It is also prospectively associated with disordered eating, body dissatisfaction, reduced physical activity, and sleep issues (Blanchard et al., 2023; Bozzola et al., 2022; de Vries et al., 2019). Further, youth with obesity are more likely to be bullied online (Sergentanis et al., 2021), so weight-based teasing may be increased through this medium. As social media is an increasingly common and integral part of many adolescents' lives (Blanchard et al., 2023), its impact on an already vulnerable population should be investigated.

Studies investigating clinical samples of treatment-seeking children and youth were excluded from the current review. Eligibility to participate in many obesity treatment programs requires the presence of a comorbid medical condition in addition to obesity; these conditions may themselves be associated with increased risk of depression, likely confounding any identified association between weight status and depression. Rates of mental health difficulties such as depression have been shown to be particularly high among this group (Galler et al., 2024; Herget et al., 2014; Sheinbein et al., 2018), and it is therefore possible that their exclusion may have truncated the range of values available for both weight status and depressive symptoms

thereby reducing the magnitude of estimated total effects across all children and youth. However, most studies that investigated clinical samples that were captured in our search did not assess weight status as an independent variable (as the samples were comprised exclusively of individuals with obesity), nor did they examine the role of mediators of the relationship between weight status and depression. It is likely that some putative mediators – such as body dissatisfaction – act as precipitants for treatment seeking and may be so common that minimal variability across participants could reduce the likelihood of detecting mediation effects. As this population is particularly at risk of negative health outcomes, future research should employ designs that allow the examination of mediation pathways specifically among weight-based treatment seeking youth in comparison to non-treatment seekers with obesity and those within the normal weight range

Another limitation pertains to the types of mediation analysis conducted by studies included in the review. Reports were eligible for inclusion if they conducted formal mediation analysis, using any statistical method to identify potential effects. The most common method used in the included studies was the causal steps approach (Baron & Kenny, 1986). This early approach outlines a series of conditions which must be satisfied for mediation to occur, one of which requires a significant effect of the independent variable on the dependent variable (i.e., the total effect). This requirement has been challenged as being overly stringent because it ignores situations where indirect and direct effects with opposing signs attenuate the total effect (for example, in cases of statistical suppression or multiple mediator models with opposing direction of effect; Fairchild & McDaniel, 2017; MacKinnon et al., 2002). This translates to low power to detect true effects in small samples and increased likelihood of Type II errors (MacKinnon et al., 2002). Thus, it is possible that studies employing this method failed to identify mediation effects

that were present but overlooked because of non-significant total effects. In the current review, this risk was somewhat mitigated by the process of grading the strength of evidence: when evaluating the precision of findings, the power to detect effects based on statistical approach and sample size was considered in determining final grades (see Appendix H). Future research should employ the use of more sophisticated statistical approaches to assess mediation (e.g., the product of coefficients approach with bias-corrected bootstrapping) that demonstrate higher power to detect effects (see Fairchild & McDaniel, 2017).

The prominence of the causal steps approach impacts both qualitative synthesis, which involves examining the statistical significance of effects, and, indirectly, quantitative synthesis by means of reporting bias. When results fail to meet the causal steps criterion of a significant total effect of an independent variable on a dependent variable, some authors do not report estimates for the indirect effect pathways of the mediator (because a conclusion has already been reached regarding a lack of mediated effect). This form of reporting bias prevents these estimates from being included in meta-analysis, which seeks to pool estimates regardless of their statistical significance. Additionally, very few included studies reported the variance or standard error for estimates of the indirect effect, which are typically used to compute the weighted mean of effects in conventional random effects meta-analysis (Borenstein, 2013). Within-study variance could therefore not be computed in the current meta-analysis, and an alternative approach was adopted where each individual effect estimate was weighted only by sample size. Going forward, this can be addressed by adopting an open science approach (specifically open data, i.e., providing open access to methods, code, and anonymized data) to maximize replicability and reproducibility of results, facilitate evidence synthesis, and reduce the risk of reporting bias.

Finally, none of the studies included in this review reported data for participants outside of traditional binary ‘male’ and ‘female’ gender categories. While this is likely reflective of the publication dates of studies captured in the literature search, it nonetheless represents a shortcoming in our understanding of a process that may be impacted by one’s gender identity and how this interacts with sociocultural ideals. As gender non-conformity can be associated with concerns related to body image and eating behaviours (Heiden-Rootes et al., 2023) and can have important implications for weight-focused medical and psychological treatment, a better understanding of how causal mechanisms apply to this population is important. This could be achieved by conducting more nuanced analysis of gender-related constructs consistent with best research practices (Lowik et al., 2022).

Concluding Statement

Obesity and mental health problems co-occur with such frequency in young people that some researchers have labelled the phenomenon an ‘epidemic within an epidemic’ (McElroy, 2015). Children and adolescents in larger bodies are particularly vulnerable to developing depression (Quek et al., 2017; Sutaria et al., 2019), although the means through which this risk is conferred remain poorly understood. Given that healthcare resources are finite and often scarce, services should be delivered that have the highest likelihood of improving outcomes. In the context of protecting and treating the mental health of children and youth with overweight and obesity, a clearer understanding of which psychosocial and behavioural variables contribute to the development of depressive symptoms in this population could inform effective service delivery. The purpose of this thesis was to identify these mediating variables through a systematic review of the scientific literature.

This systematic review and meta-analysis provides a novel contribution to the literature by: a) synthesizing and critically appraising disparate research findings across a broad range of possible psychosocial and behavioural mediators specifically applicable to children and adolescents, b) examining whether these support the application of a model of adolescent depression in explaining the link between weight status and depression in this population, and c) investigating whether the strength of these mediation pathways is moderated by gender, developmental stage, and culture. It is the first to combine quantitative meta-analysis with qualitative synthesis, rate the risk of bias of individual studies based on objective criteria, and evaluate the strength of the evidence using a structured tool. Review findings confirmed the existence of a relationship between weight status and depressive symptoms, and the mediating role of psychosocial and behavioural variables. Results also counter prevailing expectations that these pathways are more applicable to females compared to males and provide partial support for the GAM in explaining this relationship. Similar effects were identified for cognitive, behavioural, and social mediators, with a specific mediating role of body dissatisfaction, weight-based teasing, and dieting. These findings highlight the importance of moving beyond diet- and weight loss-focused interventions and adopting a more comprehensive and holistic approach that targets psychosocial health and quality of life, consistent with the World Health Organization definition of health (Schramme, 2023; World Health Organization, 1948). Future research should investigate a wider range of potential mediators and clarify the role of contextual factors such as culture and developmental stage in shaping mediation pathways, using longitudinal designs and sophisticated techniques for testing mediation. Taken together, this work endeavours to move toward a better understanding of the mechanisms linking obesity and mental health, which ultimately translate to improved care for a vulnerable population of children and youth.

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Appendix A: Systematic Review and Meta-Analysis Protocol

Psychosocial and Behavioural Mediators of the Link Between Obesity and Depression in Childhood and Adolescence: A Systematic Review and Meta-Analysis Protocol

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Abstract

Obesity occurring early in life has been associated with an increased risk for experiencing depression, particularly among female youth (Sutaria et al., 2019). The mechanisms through which this association manifests remain poorly understood. This protocol outlines the proposed methodology for a systematic review and meta-analysis which seeks to identify and evaluate the role of psychosocial and behavioural mediators of the link between obesity and depression in children and youth. Literature searches of MEDLINE, CINAHL, PsycINFO, and PubMed were conducted and updated by an experienced librarian (MS) using a peer-reviewed search strategy. Studies will be considered eligible for inclusion if they use formal mediation analyses to assess the impact of any psychological, social/interpersonal, and/or behavioural variable(s) on the association between weight status and depression. Relevant reports will be original publications written in English, employing observational or descriptive designs, with participants between the ages of five and 18 years (or 22 years if the report describes the follow-up of longitudinal data). Random effects models will be used to estimate overall and prespecified subgroup (mediator type, individual mediators, moderation by sex) effects. Risk of bias of individual studies will be dually assessed using checklists from the Joanna Briggs Institute suite of critical appraisal tools (Moola et al., 2020). Confidence in the cumulative evidence will be assessed using a Best Evidence Rating System (Quek at al., 2017). The findings will clarify the relative importance of different types of mediators, assess the applicability of the gender additive model of depression (Stice & Bearman, 2001) to these constructs, and ultimately identify important areas of focus for intervention and prevention efforts among vulnerable children and youth.

Keywords: Overweight, weight status, depressive symptoms, mediation, gender additive model

Psychosocial and Behavioural Mediators of the Link Between Obesity and Depression in Childhood and Adolescence: A Systematic Review and Meta-Analysis Protocol

Global rates of childhood obesity have been increasing dramatically. In 1975, just under 1% of children and adolescents aged 5 to 19 years were considered to have obesity; in 2016, this figure rose to 6-8% – or 124 million young people (World Health Organization, 2021). This prevalence is projected to increase to 206 million by 2025 (Lobstein & Brinsden, 2019). Overweight in childhood is likely to continue into adulthood, when elevated BMI is associated with a variety of negative health outcomes including heart disease, stroke, musculoskeletal disorders, and several types of cancer (NHLBI, 1998; Williams et al., 2015; World Health Organization, 2021). Health complications among children with obesity, including type II diabetes, early markers of cardiovascular disease, breathing difficulties and even fatty liver disease, are themselves appearing earlier than ever before (Childhood Obesity Foundation, 2019; Sahoo et al., 2015; World Health Organization, 2021).

Beyond these impairments in physical health, the impact of obesity on mental health outcomes has received increased scientific attention. Early studies revealing that weight-based stigma begins as young as kindergarten (see Brownell et al., 2005) contributed to a common hypothesis that children and youth with excess weight experience elevated levels of psychological distress compared to their normal weight peers (e.g., Liem et al., 2008; McElroy et al., 2004; Wardle & Cooke, 2005). Indeed, early onset obesity has been linked to increased risk of body dissatisfaction, bullying, stigma and discrimination, difficulties with peer relationships, low self-esteem, anxiety, depression, disordered eating and unhealthy weight-control behaviours, reduced quality of life, and even suicidal ideation (Hebebrand & Herpertz-Dahlmann, 2009;

Kalarchian & Marcus, 2012; Puhl & Latner, 2007; Sagar & Gupta, 2018; Vander Wal & Mitchell, 2011; Wardle & Cooke, 2005). Among these, the most widely studied psychological outcome is depression.

A recent meta-analysis of 22 community-based observational studies examined whether children with overweight/obesity were at increased risk of depressive symptoms compared to normal weight peers (Sutaria et al., 2019). They found children with obesity were 1.32 times more likely to exhibit depression than children of normal weight. Studies employing longitudinal designs (k=10) yielded somewhat higher odds of depression in children with obesity (OR=1.51, CI 1.21-1.88) than cross-sectional studies (OR=1.26, CI=1.09-1.45, k=12 studies) (Sutaria et al., 2019). Further subgroup analyses revealed a particularly elevated risk for females (OR = 1.44, 95% CI 1.17 to 1.50) compared to males; no effect for overweight was identified (Sutaria et al., 2019).These findings echoed findings by Quek, Tam, Zhang, and Ho (2017), who systematically reviewed 18 studies and found an increased risk of depression among children and adolescents with obesity, particularly among females, and no significant additional risk for those with overweight. Rao and colleagues (W.-W. Rao et al., 2019) reviewed similar evidence from studies conducted in mainland China; across 18 cross-sectional studies (and baseline data from longitudinal studies), they found that young people with obesity and overweight were 1.37 and 1.88 times more likely to suffer from depression, respectively, than their lower weight counterparts. In contrast, another review by Moradi, Mozaffari, Askari, and Azadbakht (2022) found no overall association between obesity and risk of depression, however subgroup analyses indicated that obesity was associated with increased risk of depression when stratified by gender, geographic location, study design and quality assessment score of individual studies. Critically, there was some overlap in included studies among these reviews (Moradi et al., 2022; Quek et

al., 2017; W.-W. Rao et al., 2019; Sutaria et al., 2019) – though perhaps not as much as might be expected – so their results cannot be considered mutually exclusive. Additionally, notable heterogeneity was identified in several analyses, indicating that results should be interpreted with some caution.

These results suggest that there is relatively consistent evidence that obesity increases the risk for depressive symptoms among children and adolescents, particularly for those at the higher end of the weight spectrum and for females. This risk of comorbidity raises several concerns. Like obesity, major depressive disorder has been shown to persist into adulthood (Lewinsohn et al., 2003; Weissman et al., 1999). Early onset depression is associated with suicidal ideation and behaviours, academic problems, social withdrawal, substance abuse, and lower quality of life (Afifi et al., 2005; Hammen et al., 2014; U. Rao & Chen, 2009). These impairments can be especially damaging during crucial periods of cognitive and social development such as adolescence (Kovacs & Goldston, 1991). Further, depressive symptoms may include decreased energy, decreased motivation, low self-efficacy, changes in appetite, difficulty concentrating, and feelings of helplessness or worthlessness (American Psychiatric Association DSM-5 Task Force & American Psychiatric Association, 2013), all of which may interfere with engaging in health promoting behaviours or even weight management treatment. For example, Zeller and colleagues (M. Zeller et al., 2004) found that adolescents with obesity who withdrew from a weight management treatment (55% of those initially enrolled) reported significantly greater depressive symptomatology than program completers, independent of degree of overweight. Self-reported depressive symptomatology has also negatively predicted the number of treatment sessions attended by children and adolescents enrolled at a family-based weight management clinic (Jensen et al., 2012).

Such negative influences on children's well-being warrant attention. To improve mental health outcomes for the growing number of children and youth with obesity, early intervention and even prevention efforts must be focused on interrupting the process through which weight may contribute to depression. However, the nature of these processes remains unclear. One important consideration is the role of biological phenomena thought to be activated in both obesity and psychiatric disorders. Examples of these phenomena include the alteration of the inflammatory system (increased levels of C-reactive protein and pro-inflammatory cytokine IL-6), neuroprogression, neurotransmitter imbalances, increased oxidative stress, and dysregulation of the hypothalamic-pituitary-adrenal axis (see Lopresti & Drummond, 2013; Reeves et al., 2008). Support for such biological mechanisms continues to develop and is bolstered by a finding that "metabolically healthy" individuals with obesity may not be at increased risk for depression (Hamer et al., 2012). Nonetheless, it is unlikely that these pathways account for all the co-variation between obesity and depression, particularly in children and adolescents who may not have had sufficient exposure to obesity to have developed these sometimes-chronic biological dysregulations. Instead, it is likely that these mechanisms are complex and interact with other genetic, environmental, psychological and social factors (Lopresti & Drummond, 2013).

Several models have been proposed which attempt to explain the role of such psychosocial and behavioural mechanisms. Stunkard, Faith and Allison (2003) strongly advocated for the investigation of moderation and mediation effects to clarify the causal pathways between obesity and depression. They outlined the role of eating and physical activity, appearance-related teasing, disordered eating, and stress as mediators through which excessive weight contributes to the development of depressive symptoms (Stunkard et al., 2003).

Markowitz, Friedman and Arent (2008) proposed a model which includes two hypothetical pathways through which obesity may influence depression: the "health concern" pathway which emphasizes the importance of functional impairment and self-rated health, and the "appearance concern" pathway which includes factors such as stigma, body image dissatisfaction and repeated dieting. Again, this model was specific to adults. Napolitano and Foster (2008) expanded on this model, by delineating four unique mediating pathways – social, behavioural, cognitive, and physiological – and specifying that the evidence base for children and youth suggested that only behavioural (e.g., physical activity) and cognitive (e.g., body image dissatisfaction and self-esteem) are likely applicable to this population.

These models generally lack a theoretical rationale for why and how variables may interact in this process and have largely not been empirically tested. Perhaps the most comprehensive model of these relationships is the *gender additive model of depression* (Stice & Bearman, 2001), based on the dual pathway model of bulimia (Stice, 1994; Stice, Nemeroff, & Shaw, 1996). The authors posit that the increased prevalence of depression among females that reliably emerges during adolescence can be explained by factors associated with pubertal weight gain. More specifically, higher body weight is associated with social pressure to be thin, which leads to an internalization of the thin ideal, body dissatisfaction, and a pattern of eating disturbances which interact to increase risk of mood issues differentially among girls compared to boys (Stice & Bearman, 2001).

The extent to which these models, in part or in whole, are supported by scientific evidence is unclear. Research findings are disparate, often investigating single mediators, with different populations, using different measures. Preiss, Brennan and Clarke (2013) systematically reviewed the literature investigating biopsychosocial variables associated with obesity and

depression specifically in adults. Results from 46 studies of mediators, moderators, predictors and correlates indicated that severity of obesity, body image, socioeconomic status, psychological factors, physical health, interpersonal effectiveness, binge eating and the experience of stigma were "consistently" associated with the relationship between obesity and depression, while support was "equivocal" for variables such as sex, ethnicity and physical activity (Preiss et al., 2013). The authors explicitly excluded studies of participants younger than 18 years from their review, arguing that that variables influencing the relationship between obesity and depression in children and adolescents may be "qualitatively different" than those of relevance to adult populations. Napolitano and Foster (2008) also suggested that factors of relevance to adults may have little effect on young people, and that comparatively less scientific attention has been paid to children and youth than their adult counterparts. Thus, a review of the mediational evidence specifically conducted with children and youth is warranted.

Objectives

The objective of this systematic review is to identify, evaluate, and synthesize the scientific evidence investigating the role of psychosocial and behavioural variables that mediate the relationship between overweight/obesity and depression specifically relevant to children and youth. These mediators may include any cognitive (e.g., weight perception, body dissatisfaction, internalization of a thin ideal), social/interpersonal (e.g., weight-based teasing, experience of stigma, low perceived peer support), and behavioural (e.g., dieting, physical activity) variables. This will be accomplished by only including studies which employ the use of statistical mediation analyses, designed to explain *how* or *why* a predictor variable exerts influence on an outcome variable (Frazier et al., 2004; Hayes, 2013). A secondary aim is to evaluate whether the components of the *gender additive model* (Stice & Bearman, 2001) – specifically, pressure to be

thin, internalization of a thin ideal, body dissatisfaction, eating disturbances, and eating disorder symptoms – are supported by available evidence. Finally, a third objective based both on the premise of the *gender additive model* (Stice & Bearman, 2001) and findings that consistently demonstrate a gender difference in this relationship (Moradi et al., 2022; Quek et al., 2017; W.-W. Rao et al., 2019; Sutaria et al., 2019), is to examine whether these proposed pathways differ for males and females. This will be accomplished through subgroup analyses for each proposed mediator in the identified literature.

Methods

The methodology for this systematic review will be informed by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Checklist (Page et al., 2021).

Eligibility Criteria

The selection criteria for inclusion in this review are as follows:

Population

School-aged children and adolescents between the ages of five and 18 years, or up to 22 years for studies conducting a longitudinal follow-up of participants initially assessed prior to age 18. Clinical samples seeking treatment for weight management will be excluded, as this group is expected to exhibit higher levels of mental health difficulties that may not be representative of the general population (Fitzgibbon et al., 1993; M. H. Zeller et al., 2006). Special populations, such as samples restricted to individuals with pre-existing comorbid medical or mental health difficulties, will also be excluded.

Study Design and Report Characteristics

Original publications written in English examining primary or secondary data will be included. Acceptable study designs will include descriptive (i.e., case series) and observational

(i.e., cross-sectional, longitudinal, case-control) designs. Systematic reviews, narrative reviews, editorial reviews, abstracts, clinical practice guidelines and grey literature will be excluded, as will reports of single case studies. Comparative results from clinical trials, or the implementation of interventions aimed at addressing weight status and/or mental health outcomes will be included only if baseline data is eligible for inclusion. Reports describing only qualitative data will be excluded.

Exposure and Outcomes

Included studies must state as their primary or secondary objective the investigation of psychosocial and/or behavioural variables influencing the relationship between weight status (i.e., overweight and/or obesity) and depression. As we are interested in examining how the experience of excess weight contributes to the experience of depression in young people, only studies which employed mediation analyses, in which weight was assessed as the independent variable, will be included. Established methods for mediation analysis include but are not limited to: the causal steps approach (Baron & Kenny, 1986), the product of coefficients approach (also known as the Sobel Test; Sobel, 1982), the distribution of the product approach (MacKinnon et al., 2002), the bootstrapping method (Preacher & Hayes, 2004), and structural equation modelling. Investigations of both single and multiple mediation models will be considered relevant.

Weight status may be assessed using any measurement protocol (i.e., objective measures or self-report) and any standard for the classification of overweight/obesity will be accepted. Any operational definition of depression (i.e., presence of symptoms, clinical diagnoses), as assessed by any instrument or protocol, will be deemed relevant for inclusion.

Information Sources

Initial searches were conducted on August 22, 2014, using the EbscoHOST interface: MEDLINE, CINAHL and PsycINFO. Searches were limited to articles published in English. As well, several PubMed subsets were searched to identify material not yet included in MEDLINE (Duffy et al., 2014). The MEDLINE search strategy was developed by a librarian experienced in systematic review searching, and peer reviewed by another librarian, using the PRESS standard (McGowan et al., 2010). The MEDLINE search was then adapted for the other database. An update was conducted December 17, 2020. The MEDLINE and PsycINFO searches were translated to the Ovid interface, CINAHL was updated in the EbscoHost database. The PubMed search was not repeated as the newest material from PubMed is present in Ovid MEDLINE. The search strategies are presented in Appendix B. Reference lists of eligible studies will also be examined.

Study Records

Data Management

Records were initially downloaded to Reference Manager (Thompson Reuters) for duplicate removal and exported into Excel (Microsoft) for screening. The record set has been subsequently transferred into a web-based software platform, Covidence (Veritas Health Innovation), for screening. Records will be managed in Zotero (Corporation for Digital Scholarship). Data extraction will be performed using piloted data extraction forms in Microsoft Excel to capture information required for planned synthesis.

Selection Process

Screening will be performed in two steps (title and abstract, then full-text) against eligibility criteria established *a priori* (see above) by two independent reviewers, in order to minimize the potential for selection bias (Wright et al., 2007) and maximize the reproducibility

of screening decisions (Lefebvre et al., 2022). Disagreements will be resolved by consensus, and, if necessary, by consultation with a third reviewer (Dr. Gary Goldfield).

Screening protocols and eligibility criteria will be pilot tested on a small sample (5%) of identified reports to ensure they serve to accurately differentiate relevant from irrelevant reports and to confirm that they can be applied reliably by multiple reviewers. Reports in the pilot sample will be screened by two reviewers, and inter-rater reliability will be calculated using the percent agreement approach. Should this rate fall below 80% (McHugh, 2012), the eligibility criteria will be adapted as necessary and the reviewers re-trained in their application.

Data collection process

Data will be extracted into form templates using Microsoft Excel (see Appendix C). These forms will be piloted by two members of the investigative team (Angela Wilson and Fatima Mougharbel) on four eligible studies and modified as necessary. Relevant data from all remaining eligible studies will be extracted by the primary investigator (Angela Wilson), and all extracted data will be verified for accuracy and completeness by a second member of the investigative team. Authors of included studies will be contacted to provide relevant unpublished data should this not be described in the published reports.

Data Items

The following data will be extracted from each study, as available:

a) Study demographics
    - Author name and year of publication
    - Study reference identification number
    - Country of origin
b) Study design and sample characteristics

- Type of design and length of follow-up(s)
- Population
- Sample size
- Name of larger community study (if applicable)
- Age range
- Sex distribution
- Ethnicity distribution

c) Weight Status

- How weight was assessed (objective measurement vs self-report)
- Operational definition of overweight/obesity (standards/cut-offs used, continuous vs. categorical data)

d) Depression

- How depression was assessed (measurement tool, method of administration)
- Operational definition (symptoms vs. diagnosis, cut-off score, continuous vs. categorical data)

e) Mediators

- Variable name(s)
- Measurement tool
- Operational definition
- Type of mediation analysis conducted
- Direction of proposed association

f) Covariates/moderators/other variables

- Variable names and description

g) Quantitative Estimates

- Total effect of weight status on depression (i.e., without controlling for effect of measured mediators)
- Indirect effect of proposed mediator(s) on the relationship between weight status and depression
- Direct effect of weight status on depression (i.e., while controlling for effect of measured mediators)
- Significance of the test of mediation (i.e., change in the significance of the total effect when the indirect effect is taken into account) OR of the proposed mediation model
- Effect of gender on relationship between weight status and depression (if applicable)

Outcomes and prioritization

The main estimates for which data will be sought are:

a) Size and significance of the relationship between weight status and depression, without controlling for the effect of proposed mediator(s) (i.e., total effect).

b) Size and significance of the relationship between weight status and each mediator in the proposed model (i.e., path *a* in mediation modelling).

c) Size and significance of the relationship between each mediator in the proposed model and depression (i.e., path *b* in regression modelling).

d) Estimate of the indirect effect of each mediator in the proposed model on the relationship between weight status and depression. This may be reported as an overall estimate or may need to be calculated as the product of *a***b*, reported individually.

e) Estimate of the direct effect of weight status on depression

f) Results and significance of each test of mediation, and/or significance of the proposed mediation model(s) (i.e., in cases where path analysis or structural equation modelling was employed). In concept, this is a measure of whether inclusion of the mediator variable in the model meaningfully reduces the strength of the relationship between weight status and depression (i.e., total effect), suggesting that the variable does in fact act as a mechanism through which weight status influences the appearance of depressive symptoms. If the mediation is shown to be "successful", the strength of the total effect will either be reduced to zero (full mediation), or significantly reduced (partial mediation).

g) Correlations/covariances between weight, proposed mediators, and depression scores (if available)

h) Effect of gender on relationship between weight status and depression (if applicable). This will be determined either by examining the above outcomes broken down by sex, or by examining the results and significance of moderation analyses by sex.

Risk of bias in individual studies

Risk of bias will be assessed at the study level, and its impact on the summarized evidence will be presented in both the results and discussion sections of the manuscript. Assessing the risk of bias in observational studies is particularly challenging, as these include a variety of designs each with their own potential sources of bias (Sterne et al., 2022; Viswanathan et al., 2017). Sanderson, Tatt, and Higgins, (2007) reviewed quality assessment tools designed for use with observational studies. While they identified over 86 tools, they concluded that no "gold standard" instrument exists that can be applied reliably across different designs, that little

consensus on critical items for risk of bias assessment has been achieved, and that most tools require adaptations to fit the needs of individual reviews. Considering this, and after having reviewed several possible tools (e.g., Newcastle-Ottawa Scale, ROBINS-I, National Heart, Lung, and Blood Institute Quality Assessment Tool), two items from the Joanna Briggs Institute suite of critical appraisal tools were selected: 1) checklist for analytical cross-sectional studies (Moola et al., 2020; see Appendix D), and 2) checklist for cohort studies (Moola et al., 2020; see Appendix E). Instructions were supplemented with guidance from the ROBINS-I (Sterne et al., 2016) and Cochrane Handbook for Systematic Reviews of Interventions (Boutron et al., 2022) to aid with interpretation of risk of bias items.

Risk of bias assessment will be conducted by two reviewers (Fatima Mougharbel and Angela Wilson). Disagreements will be resolved by consensus. The process will be piloted on a small sample of included studies (2 with cross-sectional designs, 2 with longitudinal designs) to ensure the tool is easy to use and adequately captures risks of bias inherent to the topic and study design. Given that the anticipated number of included studies will be relatively small, analyses will not be restricted to only those studies that demonstrate a low risk of bias.

Data synthesis

The primary objective of this review is to examine psychosocial and behavioural mechanisms through which weight contributes to the experience of depression in young people. An overall effect of mediation across all studies would provide evidence of *whether* weight status influences depression by way of intermediate variables, but not be able to identify *which* variables may be most important to this process. Additionally, each included study will likely examine a different subset of mediating variables based on the proposed models they are evaluating, necessitating separate analyses for studies investigating similar constructs. Therefore,

the following analyses will be conducted: a) the overall mediation effect of all proposed mediators on the relationship between weight status and depression, b) subgroup analyses to evaluate the relative strength of evidence for each type of proposed mediator (i.e., cognitive, social/interpersonal, and behavioural mediators), and c) separate subgroup analyses for individual mediators investigated by a minimum of three independent reports.

Previous work has consistently established that the link between weight and depression tends to be stronger in females (e.g., Quek et al., 2017; W.-W. Rao et al., 2019; Sutaria et al., 2019). As such, subgroup analyses examining each relevant outcome separately for males and females will be conducted (where $k \geq 2$ for each subgroup). Since the number of included studies is anticipated to be insufficient to conduct sensitivity analyses, we have not planned to assess whether the review findings are influenced by arbitrary review decisions (e.g., including only studies that employed the use of objective measurement for weight). In all cases, statistical heterogeneity will be assessed using the I^2 statistic. Quantitative synthesis will not be carried out where I^2 levels exceed 80%, which indicates that a considerable amount of variability in the effect estimates is attributable to heterogeneity and not chance (Deeks et al., 2023).

Should quantitative synthesis be considered appropriate, random effects meta-analysis will be utilized, given expected heterogeneity among studies. If correlation matrices are available for extraction, a two-step structural equation modelling framework will be used wherein the correlation matrices are first synthesized across studies, then a structural mediation model is fit to the pooled correlation matrix (Cheung, 2022; Cheung & Cheung, 2016; Gu et al., 2015). This will be conducted using the metaSEM package in R (Cheung, 2015). If correlation matrices are not provided, and bivariate correlations cannot be calculated using the available data, a

parameter-based approach will be used. This entails calculating standardized indirect and direct effects for each outcome, and conducting meta-analyses on these effect sizes (Cheung, 2022).

A narrative synthesis of the evidence for each proposed mediator, including a critical appraisal of the risk of bias, will be presented in text and table format in conjunction with any possible quantitative syntheses.

Meta-bias(es)

Given that separate analyses will be conducted for each proposed mediating variable, and we anticipate the number of included studies per variable will be small, no statistical analyses of meta-biases (for example, publication bias or selective reporting bias) are planned.

Confidence in cumulative evidence

The strength of the cumulative body of evidence for each proposed mediator will be assessed using a best evidence synthesis rating system (Quek et al., 2017; W.-W. Rao et al., 2019; Sutaria et al., 2019). This system takes into consideration the following factors for each outcome: risk of bias and study quality, number of studies investigating the outcome, and consistency of findings. Evidence is then graded as *strong* (consistent findings in 2 or more high quality studies), *moderate* (consistent findings in one high quality study and at least one low quality study, or consistent findings in multiple low-quality studies), or *insufficient* (only one study available, or inconsistent findings in 2 or more studies).

Discussion

This study aims to provide a better understanding of how and why weight status contributes to depressive symptoms in young people. While several possible mechanisms have been proposed in the literature, the relative importance of each remains unknown. Identifying the variables of greatest influence can serve to direct the focus of weight-based treatments, with the

aim of reducing comorbid mental health difficulties, improving quality of life, and maximizing engagement in health promoting behaviours and treatment. Prevention efforts can also be directed toward interrupting these processes, and early screening of children and adolescents who exhibit both obesity and other risk factors can identify those individuals who could benefit from increased services to prevent mood-related difficulties. The findings will be of relevance to health professionals who work with young people facing weight challenges, mental health service providers, teachers and even parents to guide early identification of young people likely to be at highest risk for negative mental health outcomes. Finally, this review seeks to identify gaps in our knowledge about the role of different variables that influence the relationship between obesity and depression, which may guide future research efforts in the area. The overall goal is to increase our understanding of these complex conditions, and ultimately inform evidence-based services that may improve outcomes for children and youth who are living in larger bodies.

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Appendix B: Methodological Changes to Proposed Review Protocol

The following is a list of methodological changes made to the proposed review protocol that were deemed necessary after data extraction and statistical planning was complete.

Topic	Method Proposed in Protocol	Change and Rationale
Statistical Analysis	Two-stage structural equation modelling (TSSEM; M. W.-L. Cheung, 2022) approach, which involves first pooling correlation or covariance matrices from individual studies then fitting a mediation model to the average correlation matrix using structural equation modelling	*Rationale*: Only a small number of studies reported the correlation or covariance matrices necessary for this type of analysis. Authors were contacted to request this information; however few authors responded and those who did were unable to provide the requested information. Proceeding with the TSSEM approach would necessarily remove several studies from meta-analysis (i.e., those that did not report correlation matrices), leading to increased risk of sampling bias and lack of power in detecting statistically significant results from the available data *Update*: Two random-effects meta-regressions were used to compute a weighted mean of a) the pooled indirect effects of all eligible mediators, and b) the total effects of weight status on depressive symptoms from all eligible studies.
Statistical Analysis of Heterogeneity	Use of the I^2 statistic to evaluate statistical heterogeneity	*Rationale*: The I^2 statistic is calculated within-study variance, which was not available in the current dataset. *Update:* After consultation with a statistical expert, a newer meta-analysis

Topic	Method Proposed in Protocol	Change and Rationale
		approach (Haslam et al., 2020; Nakagawa et al., 2023) was used to assess heterogeneity by examining the dispersion of confidence intervals across included effect estimates, as greater heterogeneity yields a wider ranging confidence interval
Assessment of Publication Bias	No analysis planned due to anticipated small *n* and missing within-study variance	*Rationale:* Reporting bias is important to assess in studies using statistical mediation, particularly of secondary datasets. However, no specific measures exist which are applicable to observational studies. *Update:* Publication bias is one component of reporting bias that was assessed using a visual inspection of a funnel plot.
System for Rating the Strength of Evidence	Use the Best Evidence Rating System (BESRS)	*Rationale:* BESRS provides a framework through which to combine significance estimates (vote counting) but is not a formal system through which to evaluate the strength of a body of evidence. *Update:* An adapted version of the "Evidence-Based Practice Centers Framework for Grading the Strength of Evidence" created by the Agency for Healthcare Research and Quality (EPC-AHRQ; Berkman et al., 2013) was adopted to evaluate the strength of evidence synthesized in this review. This tool is based largely on the GRADE approach, while providing specific guidance regarding the evaluation of observational evidence.

Appendix C: Electronic search strategies

2014 Search Strategies

MEDLINE

(MH "Overweight+") AND (MH "Depression" OR MH "Depressive Disorder+") AND (child* OR adolescen*) Limiters - English Language

CINAHL

(MH "Obesity+" or overweight or overweight or body mass index or bmi or adiposity or waist circumference or waist ratio or skin fold) AND ((MH "Depression+") OR (depression or depressive)) AND (child* OR adolescen*) Limiters - English Language; Exclude MEDLINE records; Publication Type: Journal Article

PsycINFO

(DE "Overweight" OR DE "Obesity") AND (DE "Major Depression" OR DE "Anaclitic Depression" OR DE "Dysthymic Disorder" OR DE "Endogenous Depression" OR DE "Postpartum Depression" OR DE "Reactive Depression" OR DE "Recurrent Depression" OR DE "Treatment Resistant Depression" OR DE "Atypical Depression" OR DE "Depression (Emotion)") AND ((child* OR adolescent*) or AG (child* OR adolescen*)) Limiters - Publication Type: Peer Reviewed Journal, Peer-Reviewed Status-Unknown; English

PubMed

(pubstatusaheadofprint or publisher[sb] or pubmednotmedline[sb]) and (obesity or obese or overweight) and (depression or depressive) and (child* OR adolescen*)

2020 Search Strategies

MEDLINE (1946 to December 15, 2020) and APA PsycINFO (1806 to December Week 1 2020)

Note: Searches were conducted using an Ovid multi-database search and duplicate records were removed online giving preference to MEDLINE, with no field preference. Lines 1-2 are optimized for MEDLINE. Lines 3-4 are optimized for Embase and lines 5-11 isolate the records to the database the search was designed for, combine those sets and then remove duplicate records and final isolate the records from each database again so each can be downloaded and imported into the citation manager using a database-specific import filter.

1. exp Overweight/ and (Depression/ or exp Depressive Disorder/) and (child* or adolescen*).mp.
2. limit 1 to english language
3. (Overweight/ or Obesity/) and (exp Major Depression/ or Atypical Depression/ or "Depression (emotion)"/) and (child* or adolescent*).mp.
4. limit 3 to (("0110 peer-reviewed journal" or "0130 peer-reviewed status unknown") and english)
5. 2 use medall
6. 4 use psyh
7. 5 or 6

8. limit 7 to yr="2013-2021"
9. remove duplicates from 8
10. 9 use medall
11. 9 use psyh

CINAHL

(MH "Obesity+" or overweight or over weight or body mass index or bmi or adiposity or waist circumference or waist ratio or skin fold) AND ((MH "Depression+") OR (depression or depressive)) AND (child* OR adolescen*)
Limiters - English Language; Exclude MEDLINE records; Publication Type: Journal Article
Expanders - Apply related words; Apply equivalent subjects
Search modes - Boolean/Phrase

Appendix D: Data Extraction Template and Coding Guide

List of Terms and Abbreviations

Abbreviation	Description
NR	not reported
NBD	not broken down
NA	not applicable
CT	can't tell (from information available in report)
ß (beta)	standardized regression coefficient
b	unstandardized regression coefficient
SE	standard error
n	sample size included in this specific analysis
Std Path Coefficient	path coefficient reported based on structural equation modelling or path analysis
Sig	significance level

Instructions:

1. Complete the following data extraction tables for each included report.
2. Complete a "mediation findings" table for each mediator investigated in the report.
3. The primary unit of interest is the standardized regression coefficient (ß). If unavailable, extract other available estimates along with associated error terms. Contact authors to request missing data as necessary.
4. Except for findings presented separately by gender, extract the least broken-down form of reported data. If the report divides data into other groups (e.g., stratified by developmental stage or culture) add additional columns to capture data for each group.
5. If both cross-sectional and longitudinal data are reported in a single study, extract *both* into different columns under the same study heading (columns may be added to capture this). While only one of either cross-sectional or longitudinal data from the same study will be included per meta-analysis, the type and completeness of each will determine which is included

6. Use the field “other comments/notes” to capture any special circumstances (e.g., if “full sample” estimate was comprised of restricted sample)
7. If findings for multiple different definitions/measures of weight status are reported, extract each separately by adding additional columns to the right.
8. In cases where “**CT**” (can’t tell) is used, consult additional secondary reports from larger studies for missing information (if applicable). Contact authors to clarify details or obtain missing information. Update with new information as it is received.

General Study and Sample Characteristics

Item	Description
Report Identifier	Author-Year-StudyID#
First Author	
Year of Publication	
Country	Country (province/state) where data was collected
Year(s)	Year of publication
Name of larger community study (if applicable)	If reported data was collected as part of a large-scale community-based study (e.g., Add Health), indicate the name description, and/or reference for the larger study.
Study design	Select among the following eligible designs: a) Cross-sectional/case control b) longitudinal/cohort, c) other (describe)
Length of follow-up (if applicable)	Number and length of follow-up assessments from baseline to subsequent assessments
Population	Briefly describe the population from which the sample was drawn (e.g., school-based, community-based, primary care clinics)
Total number of participants (N)	Total number of participants from whom data was collected, and whose data was used in reported analyses

Age range	Age range of participants (in years)
Sex (or gender) distribution	% of participants who identify as male/female/other
Ethnicity distribution	% of sample self-identified across categories of ethnicities assessed

Measurement Characteristics

Item	Description
Independent Variable: Weight	
Type of weight measurement (objective vs self-report)	Indicate whether weight status data was collected by: a) objective measurement, b) self-report, c) other
Unit of weight measurement (e.g., body mass index, waist circumference)	Select all units of weight measurement reported: a) body mass index (BMI), b) waist circumference, c) skinfold thickness, d) weight only, e) waist-to-hip ratio, f) other (describe)
Definition of overweight (i.e., standards, cutoffs)	Describe how is "overweight" or "obesity" (i.e., caseness) operationally defined. What standards and/or cut-offs were used?
Dependent Variable: Depression	
Depression measure	Name or description and reference of tool used to assess the presence of depression
Method of administration	Select among the following: a) self-report written, b) self-report structured or clinical interview, c) parent/caregiver report, d) teacher report, e) other (describe)
Definition of depression (i.e., standards or cut-offs used to determine "caseness")	Describe how "caseness" is operationally defined. Presence of symptoms vs clinical diagnosis? What is the time frame for presentation (i.e., current symptoms vs lifetime, etc.)? If applicable, what criteria/standards/cut-offs were used?
Other Variables	
Moderators	List and define any proposed moderators
Covariates/Other measured variables	List and define any additional variables assessed (e.g., additional dependent variables, etc.)

Item	Description
Mediation Model Describe proposed relationship(s) being evaluated (i.e., model)	

Mediation Findings

		Author-Year-StudyID#		
	(Response Options)	**Full Sample**	**Females**	**Males**
Name of mediator				
Mediator measure				
Mediator class	(Cognitive, social, behavioural)			
Statistical Analysis Used to Test mediation[1]				
Part of GAM?	*Yes/no*			
Moderation (or data stratified) by gender?				
Moderation (or data stratified) by developmental stage?				
Operational definition of developmental stage				
Moderation (or data stratified) by culture?				
Operational definition of culture				
Direct effect c'				
Beta (standardized)				
b (unstandardized)				
SE				

		Author-Year-StudyID#		
	(Response Options)	**Full Sample**	**Females**	**Males**
n				
Significant?	(yes/no/not assessed)			
Significance level				
Other type of analysis performed				
Effect Estimate				
Significant?				
Significance level				
Indirect Effect: Path *a*				
Beta (standardized)				
b (unstandardized)				
SE				
n				
Significant?	(yes/no/not assessed)			
Significance level				
Other type of analysis performed				
Effect Estimate				
Significant?				
Significance level				
Indirect Effect: Path *b*				
Beta (standardized)				
b (unstandardized)				
SE				
n				
Significant?	(yes/no/not assessed)			
Significance level				
Other type of analysis performed				
Effect Estimate				
Significant?				
Significance level				
Indirect Effect: Path *ab*				

		Author-Year-StudyID#		
	(Response Options)	**Full Sample**	**Females**	**Males**
Beta (standardized)				
b (unstandardized)				
SE				
n				
Significant?	(yes/no/not assessed)			
Significance level				
Other type of analysis performed				
Effect Estimate				
Significant?				
Significance level				
Total Effect: Path *c*				
Beta (standardized)				
b (unstandardized)				
SE				
n				
Significant?	(yes/no/not assessed)			
Significance level				
Other type of analysis performed				
Effect Estimate				
Significant?				
Significance level				
Notes and Other Findings				

[1]Indicate which statistical analyses were used to test for mediation (select all that apply): causal steps, Sobel test, bootstrapping, product of coefficients (other than Sobel), distribution of products, difference of coefficients, model fit, proportion mediated, joint significance, structural equation modelling/path analysis, other

Appendix E: JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies

Reviewer: Date: Record:

	Yes	No	Unclear	Not applicable
1. Were the criteria for inclusion in the sample clearly defined?	□	□	□	□
2. Were the study subjects and the setting described in detail?	□	□	□	□
3. Was the exposure measured in a valid and reliable way?	□	□	□	□
4. Were objective, standard criteria used for measurement of the condition?	□	□	□	□
5. Were mediators measured in a valid and reliable way?*	□	□	□	□
6. Were confounding factors identified?	□	□	□	□
7. Were strategies to deal with confounding factors stated?	□	□	□	□
8. Were the outcomes measured in a valid and reliable way?	□	□	□	□
9. Was appropriate statistical analysis used?	□	□	□	□

Overall risk of bias appraisal: Low Risk □ Moderate Risk □ High Risk □

Comments (Including reason for exclusion)

* **Indicates item added or adapted for current review**

Guidelines for Completing Analytical Cross Sectional Studies Critical Appraisal Tool (Adapted)

Response Options: Yes, No, Unclear or Not/Applicable

1. Were the criteria for inclusion in the sample clearly defined?

The authors should provide clear inclusion and exclusion criteria that they developed prior to recruitment of the study participants. The inclusion/exclusion criteria should be specified (e.g., risk, stage of disease progression) with sufficient detail and all the necessary information critical to the study.

2. Were the study subjects and the setting described in detail?

The study sample should be described in sufficient detail so that other researchers can determine if it is comparable to the population of interest to them. The authors should provide a clear description of the population from which the study participants were selected or recruited, including demographics, location, and time period.

3. Was the exposure measured in a valid and reliable way?

The study should clearly describe the method of measurement of exposure. Assessing validity requires that a 'gold standard' is available to which the measure can be compared. The validity of exposure measurement usually relates to whether a current measure is appropriate or whether a measure of past exposure is needed. Reliability refers to the processes included in an epidemiological study to check repeatability of measurements of the exposures. These usually include intra-observer reliability and inter-observer reliability.

**Adaptation for current review*: A main determinant of validity and reliability of weight measurement in this context is whether the assessment of weight was done *objectively* (i.e., someone else took physical measurements), or *subjectively* (i.e., the participant was asked to

self-report their weight or measurements). Subjective assessment of weight/adiposity is likely to be less reliable than objective methods and may be confounded when evaluated in concert with variables such as weight perception or body dissatisfaction.

4. Were objective, standard criteria used for measurement of the condition?

It is useful to determine if patients were included in the study based on either a specified diagnosis or definition. This is more likely to decrease the risk of bias. Characteristics are another useful approach to matching groups, and studies that did not use specified diagnostic methods or definitions should provide evidence on matching by key characteristics.

**Adaptation for current review*: Given the changes in height and weight that are part of natural physical development, weight measurement in children in adolescents should be interpreted relative to other young people of the same age and sex (CDC). As such, valid interpretation of weight should describe the use of a formal classification system (e.g. International Obesity Task Force, World Health Organization Child Growth Standards, Centers for Disease Control and Prevention growth charts; see de Onis & Lobstein, 2010).

5. Were the mediators measured in a valid and reliable way? *

The study should clearly describe the method of measurement of all mediators. Assessing validity requires that a 'gold standard' is available to which the measure can be compared. The validity of mediator measurement usually relates to whether a current measure is appropriate or whether a measure of past exposure is needed. Reliability refers to the processes included in an epidemiological study to check repeatability of measurements of the mediators. These usually include intra-observer reliability and inter-observer reliability.

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* **Indicates item added or adapted for current review**

**Adaptation for current review*: (Consider the following questions for each mediator assessed. Use the "notes" section to elaborate on any discrepancies, questions or particularities for each.) How was each mediator operationally defined? How was each mediator measured? Was the tool used to assess the mediator(s) previously published? Was validity and/or reliability data presented? Was the current tool a modification to an existing instrument, and if so, has the validity and/or reliability of the modified version been tested? Was the tool or question developed for purpose of the current study?

6. Were confounding factors identified?

Confounding has occurred where the estimated intervention exposure effect is biased by the presence of some difference between the comparison groups (apart from the exposure investigated/of interest). Typical confounders include baseline characteristics, prognostic factors, or concomitant exposures (e.g. smoking). A confounder is a difference between the comparison groups that influences the direction of the study results. A high-quality study at the level of cohort design will identify the potential confounders and measure them (where possible). This is difficult for studies where behavioral, attitudinal or lifestyle factors may impact on the results.

**Adaptation for current review*: Given the nature of the topic and type of design likely to be included (i.e., observational studies), it will not be possible for a study to account for all possible confounders. The following is a non-exhaustive list of variables that may be considered: sex, socioeconomic status, prior depression diagnoses, family history of overweight and/or depression, biological or genetic vulnerabilities (e.g., inflammatory markers). To be considered a low risk of bias due to confounding, the report should identify at

least 2 possible confounding variables, provide a rationale for their inclusion, and employ a strategy to account for their influence (see question #7 below).

7. Were strategies to deal with confounding factors stated?

Strategies to deal with effects of confounding factors may be dealt within the study design or in data analysis. By matching or stratifying sampling of participants, effects of confounding factors can be adjusted for. When dealing with adjustment in data analysis, assess the statistics used in the study. Most will be some form of multivariate regression analysis to account for the confounding factors measured.

8. Were the outcomes measured in a valid and reliable way?

Read the methods section of the paper. If for e.g. lung cancer is assessed based on existing definitions or diagnostic criteria, then the answer to this question is likely to be yes. If lung cancer is assessed using observer reported, or self-reported scales, the risk of over- or under-reporting is increased, and objectivity is compromised. Importantly, determine if the measurement tools used were validated instruments as this has a significant impact on outcome assessment validity.

**Adaptation for current review*: "Depression", loosely defined, is the outcome of interest. How was depression operationally defined? Did the study investigate clinical diagnoses or the presence of depressive symptoms? What instrument was used? What is the validity/reliability of the instrument? Was it modified for the current study, and if so, was reliability/validity presented for the modified version? Who was the respondent (i.e., self-report vs. parent or teacher report)?

9. Was appropriate statistical analysis used?

As with any consideration of statistical analysis, consideration should be given to whether there was a more appropriate alternate statistical method that could have been used. The methods section should be detailed enough for reviewers to identify which analytical techniques were used (in particular, regression or stratification) and how specific confounders were measured.

For studies utilizing regression analysis, it is useful to identify if the study identified which variables were included and how they related to the outcome. If stratification was the analytical approach used, were the strata of analysis defined by the specified variables? Additionally, it is also important to assess the appropriateness of the analytical strategy in terms of the assumptions associated with the approach as differing methods of analysis are based on differing assumptions about the data and how it will respond.

* *Adaptation for current review*: Established mediation analyses include but are not limited to: the causal steps approach (Baron & Kenny, 1986), the product of coefficients approach (Sobel, 1982), the distribution of the product approach (MacKinnon et al., 2002), the bootstrapping method (Preacher & Hayes, 2004), and path analysis/structural equation modelling.

***Overall risk of bias appraisal:**

No specific guidance is provided in the JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies on how overall risk of bias should be determined. The following guidance is taken from the National Heart, Lung, and Blood Institute (NHLBI REF) quality assessment tools, and provides information on factors to consider in determining overall risk of bias:

- Internal validity for cohort studies is the extent to which the results reported in the study can truly be attributed to the exposure being evaluated and not to flaws in the design or

conduct of the study–in other words, the ability of the study to draw associative conclusions about the effects of the exposures being studied on outcomes. Any such flaws can increase the risk of bias.

- Critical appraisal involves considering the risk of potential for selection bias, information bias, measurement bias, or confounding (the mixture of exposures that one cannot tease out from each other). Examples of confounding include co-interventions, differences at baseline in patient characteristics, and other issues throughout the questions above. High risk of bias translates to a rating of poor quality. Low risk of bias translates to a rating of good quality. (Thus, the greater the risk of bias, the lower the quality rating of the study.)
- The more attention in the study design to issues that can help determine whether there is a causal relationship between the exposure and outcome, the higher quality the study. These include exposures occurring prior to outcomes, evaluation of a dose-response gradient, accuracy of measurement of both exposure and outcome, sufficient timeframe to see an effect, and appropriate control for confounding–all concepts reflected in the tool.
- Generally, when you evaluate a study, you will not see a "fatal flaw," but you will find some risk of bias. By focusing on the concepts underlying the questions in the quality assessment tool, you should ask yourself about the potential for bias in the study you are critically appraising. For any box where you check "no" you should ask, "What is the potential risk of bias resulting from this flaw in study design or execution?" That is, does this factor cause you to doubt the results that are reported in the study or doubt the ability of the study to accurately assess an association between exposure and outcome?
- The best approach is to think about the questions in the tool and how each one tells you something about the potential for bias in a study. The more you familiarize yourself with

the key concepts, the more comfortable you will be with critical appraisal. Examples of studies rated good, fair, and poor are useful, but each study must be assessed on its own based on the details that are reported and consideration of the concepts for minimizing bias. (Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies.)

Moola S, Munn Z, Tufanaru C, Aromataris E, Sears K, Sfetcu R, Currie M, Qureshi R, Mattis P, Lisy K, Mu P-F. Chapter 7: Systematic reviews of etiology and risk. In: Aromataris E, Munn Z (Editors). *JBI Manual for Evidence Synthesis.* JBI, 2020.

Study Quality Assessment Tools – National Heart, Lung, and Blood Institute (NHLBI) from https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools

Appendix F: JBI Critical Appraisal Checklist for Cohort Studies

Reviewer: Date: Record:

	Yes	No	Unclear	Not applicable
1. Were the two groups similar and recruited from the same population?	□	□	□	□
2. Were the exposures measured similarly to assign people to both exposed and unexposed groups?	□	□	□	□
3. Was the exposure measured in a valid and reliable way?	□	□	□	□
4. Were confounding factors identified?	□	□	□	□
5. Were strategies to deal with confounding factors stated?	□	□	□	□
6. Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?	□	□	□	□
7. Were mediators measured in a valid and reliable way?*	□	□	□	□
8. Was temporal precedence of the exposure, mediator, and outcome established?*	□	□	□	□
9. Were the outcomes measured in a valid and reliable way?	□	□	□	□
10. Was the follow up time reported and sufficient to be long enough for outcomes to occur?	□	□	□	□
11. Was follow up complete, and if not, were the reasons to loss to follow up described and explored?	□	□	□	□

* **Indicates item added or adapted for current review**

12. Were strategies to address incomplete follow up utilized?	□	□	□	□
13. Was appropriate statistical analysis used?	□	□	□	□

Overall risk of bias appraisal: Low Risk □ Moderate Risk □ High Risk □

Comments (Including reason for exclusion)

Guidelines for Completing Cohort Studies Critical Appraisal Tool (Adapted)

Response options: Yes, No, Unclear or Not/Applicable

1. Were the two groups similar and recruited from the same population?

Check the paper carefully for descriptions of participants to determine if patients within and across groups have similar characteristics in relation to exposure (e.g. risk factor under investigation). The two groups selected for comparison should be as similar as possible in all characteristics except for their exposure status, relevant to the study in question. The authors should provide clear inclusion and exclusion criteria that they developed prior to recruitment of the study participants.

2. Were the exposures measured similarly to assign people to both exposed and unexposed groups?

A high-quality study at the level of cohort design should mention or describe how the exposures were measured. The exposure measures should be clearly defined and described in detail. This will enable reviewers to assess whether the participants received the exposure of interest.

3. Was the exposure measured in a valid and reliable way?

The study should clearly describe the method of measurement of exposure. Assessing validity requires that a 'gold standard' is available to which the measure can be compared. The validity of exposure measurement usually relates to whether a current measure is appropriate or whether a measure of past exposure is needed. Reliability refers to the processes included in an epidemiological study to check repeatability of measurements of the exposures. These usually include intra-observer reliability and inter-observer reliability.

**Adaptation for current review*: A main determinant of validity and reliability of weight measurement in this context is whether the assessment of weight was done *objectively* (i.e., someone else took physical measurements), or *subjectively* (i.e., the participant was asked to self-report their weight or measurements). Subjective assessment of weight/adiposity is likely to be less reliable than objective methods and may be confounded when evaluated in concert with variables such as weight perception or body dissatisfaction.

4. Were confounding factors identified?

Confounding has occurred where the estimated intervention exposure effect is biased by the presence of some difference between the comparison groups (apart from the exposure investigated/of interest). Typical confounders include baseline characteristics, prognostic factors, or concomitant exposures (e.g. smoking). A confounder is a difference between the comparison groups, and it influences the direction of the study results. A high-quality study at the level of cohort design will identify the potential confounders and measure them (where possible). This is difficult for studies where behavioral, attitudinal or lifestyle factors may impact on the results.

**Adaptation for current review*: Given the nature of the topic and type of design likely to be included (i.e., observational studies), it will not be possible for a study to account for all possible confounders. The following is a non-exhaustive list of variables that may be considered: sex, socioeconomic status, prior depression diagnoses, family history of overweight and/or depression, biological or genetic vulnerabilities (e.g., inflammatory markers). To be considered a low risk of bias due to confounding, the report should identify at least 2 possible confounding variables, provide a rationale for their inclusion, and employ a strategy to account for their influence (see question #7 below).

5. Were strategies to deal with confounding factors stated?

Strategies to deal with effects of confounding factors may be dealt within the study design or in data analysis. By matching or stratifying sampling of participants, effects of confounding factors can be adjusted for. When dealing with adjustment in data analysis, assess the statistics used in the study. Most will be some form of multivariate regression analysis to account for the confounding factors measured. Look out for a description of statistical methods as regression methods such as logistic regression are usually employed to deal with confounding factors/variables of interest.

6. Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?

The participants should be free of the outcomes of interest at the start of the study. Refer to the ‘methods’ section in the paper for this information, which is usually found in descriptions of participant/sample recruitment, definitions of variables, and/or inclusion/exclusion criteria.

7. Were mediators measured in a valid and reliable way?*

The study should clearly describe the method of measurement of all mediators. Assessing validity requires that a 'gold standard' is available to which the measure can be compared. The validity of mediator measurement usually relates to whether a current measure is appropriate or whether a measure of past exposure is needed. Reliability refers to the processes included in an epidemiological study to check repeatability of measurements of the mediators. These usually include intra-observer reliability and inter-observer reliability.

**Adaptation for current review*: (Consider the following questions for each mediator assessed. Use the "notes" section to elaborate on any discrepancies, questions or particularities for each.) How was each mediator operationally defined? How was each mediator measured? Was the tool used to assess the mediator(s) previously published? Was validity and/or reliability data presented? Was the current tool a modification to an existing instrument, and if so, has the validity and/or reliability of the modified version been tested? Was the tool or question developed for purpose of the current study?

8. Was temporal precedence of the exposure, mediator(s), and outcome established?*

Studies employing mediational analyses are at risk of temporal order bias, which can occur when mediators are not measured subsequent to exposure and antecedent to the outcome (Vo & Vansteelandt, 2022). In single mediator analyses, ideally this involves collecting data at three separate time points so prior levels of each variable may be statistically controlled (Cole & Maxwell, 2003).

9. Were the outcomes measured in a valid and reliable way?

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* **Indicates item added or adapted for current review**

Read the methods section of the paper. If for e.g. lung cancer is assessed based on existing definitions or diagnostic criteria, then the answer to this question is likely to be yes. If lung cancer is assessed using observer reported, or self-reported scales, the risk of over- or under-reporting is increased, and objectivity is compromised. Importantly, determine if the measurement tools used were validated instruments as this has a significant impact on outcome assessment validity.

**Adaptation for current review*: "Depression", loosely defined, is the outcome of interest. How was depression operationally defined? Did the study investigate clinical diagnoses or the presence of depressive symptoms? What instrument was used? What is the validity/reliability of the instrument? Was it modified for the current study, and if so, was reliability/validity presented for the modified version? Who was the respondent (i.e., self-report vs. parent or teacher report)?

10. Was the follow up time reported and sufficient to be long enough for outcomes to occur? The appropriate length of time for follow up will vary with the nature and characteristics of the population of interest and/or the intervention, disease, or exposure. To estimate an appropriate duration of follow up, read across multiple papers, and take note of the range for duration of follow up. The opinions of experts in clinical practice or clinical research may also assist in determining an appropriate duration of follow up. For example, a longer timeframe may be needed to examine the association between occupational exposure to asbestos and the risk of lung cancer. It is important, particularly in cohort studies that follow up is long enough to enable the outcomes. However, it should be remembered that the research question and outcomes being examined would probably dictate the follow up time.

11. Was follow up complete, and if not, were the reasons to loss to follow up described and explored?

It is important in a cohort study that a greater percentage of people are followed up. As a general guideline, at least 80% of patients should be followed up. Generally, a dropout rate of 5% or less is considered insignificant. A rate of 20% or greater is considered to significantly impact on the validity of the study. However, in observational studies conducted over a lengthy period a higher dropout rate is to be expected. A decision on whether to include or exclude a study because of a high dropout rate is a matter of judgement based on the reasons why people dropped out, and whether dropout rates were comparable in the exposed and unexposed groups.

Reporting of efforts to follow up participants that dropped out may be regarded as an indicator of a well conducted study. Look for clear and justifiable description of why people were left out, excluded, dropped out etc. If there is no clear description or a statement in this regard, this will be a 'No'.

12. Were strategies to address incomplete follow up utilized?

Some people may withdraw due to change in employment or some may die; however, it is important that their outcomes are assessed. Selection bias may occur as a result of incomplete follow up. Therefore, participants with unequal follow up periods must be considered in the analysis, which should be adjusted to allow for differences in length of follow up periods. This is usually done by calculating rates which use person-years at risk, i.e. considering time in the denominator.

13. Was appropriate statistical analysis used?

As with any consideration of statistical analysis, consideration should be given to whether there was a more appropriate alternate statistical method that could have been used. The methods section of cohort studies should be detailed enough for reviewers to identify which analytical

techniques were used (in particular, regression or stratification) and how specific confounders were measured.

For studies utilizing regression analysis, it is useful to identify if the study identified which variables were included and how they related to the outcome. If stratification was the analytical approach used, were the strata of analysis defined by the specified variables? Additionally, it is also important to assess the appropriateness of the analytical strategy in terms of the assumptions associated with the approach as differing methods of analysis are based on differing assumptions about the data and how it will respond.

**Adaptation for current review:* Established mediation analyses include but are not limited to: the causal steps approach (Baron & Kenny, 1986), the product of coefficients approach (Sobel, 1982), the distribution of the product approach (MacKinnon et al., 2002), the bootstrapping method (Preacher & Hayes, 2004), and path analysis/structural equation modelling.

***Overall risk of bias appraisal:**

No specific guidance is provided in the JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies on how overall risk of bias should be determined. The following guidance is taken from the National Heart, Lung, and Blood Institute (NHLBI REF) quality assessment tools, and provides information on factors to consider in determining overall risk of bias:

- Internal validity for cohort studies is the extent to which the results reported in the study can truly be attributed to the exposure being evaluated and not to flaws in the design or conduct of the study–in other words, the ability of the study to draw associative conclusions about the effects of the exposures being studied on outcomes. Any such flaws can increase the risk of bias.

- Critical appraisal involves considering the risk of potential for selection bias, information bias, measurement bias, or confounding (the mixture of exposures that one cannot tease out from each other). Examples of confounding include co-interventions, differences at baseline in patient characteristics, and other issues throughout the questions above. High risk of bias translates to a rating of poor quality. Low risk of bias translates to a rating of good quality. (Thus, the greater the risk of bias, the lower the quality rating of the study.)
- The more attention in the study design to issues that can help determine whether there is a causal relationship between the exposure and outcome, the higher quality the study. These include exposures occurring prior to outcomes, evaluation of a dose-response gradient, accuracy of measurement of both exposure and outcome, sufficient timeframe to see an effect, and appropriate control for confounding–all concepts reflected in the tool.
- Generally, when you evaluate a study, you will not see a "fatal flaw," but you will find some risk of bias. By focusing on the concepts underlying the questions in the quality assessment tool, you should ask yourself about the potential for bias in the study you are critically appraising. For any box where you check "no" you should ask, "What is the potential risk of bias resulting from this flaw in study design or execution?" That is, does this factor cause you to doubt the results that are reported in the study or doubt the ability of the study to accurately assess an association between exposure and outcome?
- The best approach is to think about the questions in the tool and how each one tells you something about the potential for bias in a study. The more you familiarize yourself with the key concepts, the more comfortable you will be with critical appraisal. Examples of studies rated good, fair, and poor are useful, but each study must be assessed on its own

based on the details that are reported and consideration of the concepts for minimizing bias. (Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies.)

Moola S, Munn Z, Tufanaru C, Aromataris E, Sears K, Sfetcu R, Currie M, Qureshi R, Mattis P, Lisy K, Mu P-F. Chapter 7: Systematic reviews of etiology and risk. In: Aromataris E, Munn Z (Editors). *JBI Manual for Evidence Synthesis.* JBI, 2020.

Study Quality Assessment Tools – National Heart, Lung, and Blood Institute (NHLBI) from https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools

Appendix G: Amendments and Additions Made to JBI

JBI Checklist	Modification Made
Critical Appraisal Checklist for Analytical Cross-Sectional Studies	• Add item #5 "were mediators measured in a valid and reliable way?" • "Overall Appraisal" response options changed from "include/exclude/seek further information" to "low/moderate/high risk of bias"
Critical Appraisal Checklist for Cohort (Longitudinal) Studies	• Add item #7 "were mediators measured in a valid and reliable way?" • Add item #8 "was temporal precedence of the exposure, mediator(s), and outcome established? (i.e., were at least three waves of data collected, and/or was the exposure measured prior to the mediator, and the mediator measured prior to the outcome?)" • "Overall Appraisal" response options changed from "include/exclude/seek further information" to "low/moderate/high risk of bias"

Appendix H:

Adapted EPC-AHRQ Framework for Grading the Strength of Evidence

Adapted EPC-AHRQ Framework for Grading the Strength of Evidence: Items and Coding Guide

EPC-AHRQ Item	Item Description and Coding Guide	Response Options
Summary of Findings	*Definition*: Summarize the results of quantitative and qualitative syntheses of available evidence for each research question. *To evaluate*: • Greater weight should be given to meta-analytic findings where available, considering precision/heterogeneity of these estimates • Consider the number of reports/effects contributing to findings • Provide summary judgment re: outcome/research question	Not Applicable
Study Limitations[b]	*Definition*: Degree to which included reports are protected against bias *To evaluate:* Examine risk of bias assessments for each included effect estimate for the given outcome. (Risk of Bias was assessed on a report-level basis, so all effects from a given report are assigned the same level of risk). In the event of an even distribution of Risk of Bias ratings, more weight should be given to studies with longitudinal designs.	**Low:** the majority of effects were from reports rated as having a low risk of bias **Moderate:** the majority of effects were from reports rated as having a moderate risk of bias **High:** the majority of effects were from reports rated as having a high risk of bias
Directness	*Definition*: How closely the available evidence measures the outcome of interest.	**Direct:** Finding includes some longitudinal evidence/valid measurement

	To evaluate: *General considerations:* Were effects derived primarily from cross-sectional or longitudinal studies? (Longitudinal designs are a more direct assessment of the mediation process than cross-sectional designs, because they can establish temporal precedence of independent, mediating, and dependent variables) *Developmental stage and culture subgroup analysis*: Were the operational definitions and/or measurement of the moderator groups adequate to assess the construct? (e.g., was grade level used as a proxy for developmental stage? This would indicate 'indirectness') *GAM subgroup analysis*: Were the statistical methods used adequate to evaluate the model? Did studies explicitly investigate the GAM, and if so, did they include the full model? *Individual mediators*: Were the instruments used to assess the mediator valid? Was the timeframe of the assessments appropriate?	of mediators and moderators/analysis was appropriate **Indirect:** Evidence supporting the finding is mostly from cross-sectional designs/mediators or moderators were not assessed with appropriate tools, or constructs were poorly defined/type of analysis did not adequately evaluate mediation pathways
Consistency	*Definition*: Degree to which included reports find similar magnitudes of effect (dispersion) for a given outcome *To evaluate:* This domain is typically assessed via estimates of between-study heterogeneity; either by examining whether the confidence intervals of individual studies overlap the meta-analytic summary estimate, evaluating estimates of the magnitude of statistical heterogeneity (e.g., I^2 statistic), and/or by	**Consistent:** at least 70% of effects assessed for statistical significance of the mediated effect found evidence in support of the conclusion **Inconsistent:** <70% of effects assessed for statistical significance found evidence in support of the conclusion

	examining subgroup analysis. However, these measures of dispersion were not available for individual reports included in the review. Thus, results from qualitative synthesis should be used to assess level of consistency. Following methods used by Wang and colleagues (2015), consistency should be examined using this formula: (# statistically significant results / Total # effects that reported results of significance testing for the outcome in question) *100 No minimum number of studies are required to apply this rule, however, when a small number of mediated effects was assessed for statistical significance, consider the range (magnitude and direction) of individual effects available.	**Consistency Unknown:** the body of evidence includes only a single effect tested for statistical significance, no estimates of statistical significance were available, or all available effects originate from the same study.
Precision	*Definition*: Degree of certainty surrounding an effect estimate for a given outcome *To evaluate:* • If meta-analysis was conducted for a given outcome, examine the upper- and lower-bound confidence intervals for the pooled estimate. • A confidence interval is considered *wide* if: (upper-CI – lower-CI) > 2*(average effect) • A confidence interval is considered *narrow* if (upper-CI – lower-CI) < 2*(average effect) • If meta-analysis was not possible, examine the sample size and mediation approach from individual reports to evaluate if they were adequately powered to detect an effect (based on guidance from Preacher & Kelly, 2011, and sample size by mediation approach outlined in Fritz & MacKinnon, 2007).	**Precise:** Narrow confidence interval (or ≥50% of effects in qualitative synthesis were adequately powered to detect effects) **Imprecise:** Wide confidence interval (or <50% of effects in qualitative synthesis were adequately powered to detect effects) **Precision Unknown:** (in meta-analysis) the confidence interval for pooled effects was not available, (in qualitative synthesis) unclear whether sufficiently powered/adequate sample size

Reporting Bias	*Definition*: Reporting bias results from selectively publishing or reporting research findings based on the favourability of direction or magnitude of effect. It includes publication bias, selective outcome reporting bias, and selective analysis reporting bias. *To evaluate:* Although observational studies may be subject to these sources of bias, appropriate methods do not exist through which to properly assess them. As per guidance from the EPC-AHRQ framework (Berkman et al., 2013), this domain is not required for observational studies. Instead, a general discussion of risk of reporting bias is provided for all outcomes in the "Results" section of the review.	**Not applicable**
Overall Strength of Evidence	*Definition*: Grade for strength of evidence for a single outcome. *To evaluate:* For each outcome, consider two components: a) Confidence in the estimate of effect (i.e., likelihood that the evidence reflects a true effect based on results from quantitative and qualitative synthesis) b) Level of deficiencies in the body of evidence (based on domain ratings) Describe how the major concerns in each domain did/did not contribute to overall strength of evidence. *General Considerations*:	**High:** Very confident the estimate of effect is close to the true effect for this outcome. Findings are stable and unlikely to change substantially with further evidence. **Moderate:** Moderately confident the estimate of effect lies close to the true effect for this outcome. Findings are likely to be stable but may change with additional evidence. **Low:** Limited confidence the estimate of effect lies close to the true effect for this outcome. Additional evidence is needed

	Evidence from observational studies is given an initial provisional grade of "low" strength of evidence (because of higher risk of bias than RCTs). All studies in this review are observational in nature. Strength can be upgraded to 'moderate' (and much less often, 'high') if: • Limitations/risk of bias are low-moderate • Evidence base found to be direct, consistent, and precise	before determining that the finding is stable and close to the true effect. **Insufficient:** No evidence is available, or the body of evidence has unacceptable deficiencies that preclude reaching a conclusion. *Examples:* • No included studies provide evidence re: outcome • Evidence based on only one study, especially if it has low power/mod-high risk of bias • Evidence is too weak/sparse/inconsistent to estimate an effect • Confidence interval is so wide that it includes two incompatible conclusions (i.e., significant positive and negative effects)

[a] Adapted version of framework put forward by the Evidence-based Practice Center program of the Agency for Healthcare Research and Quality (EPC-AHRQ), with instructions based on the "Methods Guide for Comparative Effectiveness Reviews" (Berkman et al., 2013).

[b] Contrary to the other domains, "low" indicates greater confidence, while "high" indicates lower confidence

Appendix I: Risk of Bias Ratings for Included Reports

Table 9

Risk of Bias Ratings: Cross-Sectional Designs

Report	1	2	3	4	5	6	7	8	9	Overall Risk of Bias
Allen (2006)	yes	Yes	yes	Yes	yes	No	no	Yes	yes	Moderate
Bang (2012)	yes	yes	yes	yes	yes	No	no	yes	yes	Moderate
Chaiton (2009)	yes	yes	yes	unclear	yes	yes	unclear	yes	yes	Low
Deepthi (2014)	No	yes	unclear	No	unclear	no	no	unclear	unclear	High
Ge (2001)[1]	yes	yes	yes	no	yes	Unclear	No	yes	yes	Moderate
Mond (2011)	yes	yes	Yes[2]	yes	Yes	No	Yes	Yes	Yes	Moderate
Needham (2005)[1]	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Low
Santos (2007)	Yes	Yes	no	no	Yes	Unclear	No	Yes	Yes	Moderate
terBogt (2006)	yes	Yes	No	Yes	Unclear	Yes	Yes	Yes	Yes	Low
Thompson (1995)[3]										
Ting (2012)	yes	Yes	Yes[2]	yes	Yes	No	Yes	Yes	Yes	Moderate
Wynne (2016)	yes	Yes	Yes	yes	Yes	No	No	Yes	Yes	Moderate
Xie (2005)	yes	Yes	Yes	Yes	unclear	No	yes	Yes	Yes	Moderate
Yen (2014)	Yes	Yes	No	yes	Yes	Unclear	Unclear	Yes	Yes	Moderate

Note: According to the JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies (Moola et al., 2020), modified for the current review, the item numbers map onto the following checklist questions: 1= Were the criteria for inclusion in the sample clearly defined?, 2= Were the study subjects and the setting described in detail?, 3= Was the exposure measured in a valid and reliable way?, 4= Were objective, standard criteria used for measurement of the condition?, 5= Were mediators measured in a valid and reliable

way?, 6= Were confounding factors identified?, 7= Were strategies to deal with confounding factors stated?, 8= Were the outcomes measured in a valid and reliable way?, 9= Was appropriate statistical analysis used?

Response Options: (items 1-9) yes; no; unclear = could not accurately rate this item based on information contained in report (and in consultation with accompanying reports and/or correspondence from authors; NR = not reported. (Overall risk of bias rating) low risk, moderate risk, high risk.

[1] Report describing results from larger National Longitudinal Study of Adolescent Health (Add Health) study. Vaughan and Halpern (2010) was selected as primary report, however risk of bias assessment was conducted on all relevant reports as some (mutually exclusive) data was extracted from each.

[2] Weight was assessed subjectively in full sample, and objectively in a sub-sample of participants. Subjective and objective measurements were statistically compared to establish relative accuracy of self-report.

[3] In Thompson (1995), both cross-sectional and longitudinal analyses were reported as separate "studies" within this report, however constructs assessed in cross-sectional analyses were not presented in a manner extractable for this review. As such, risk of bias assessment was only conducted on the longitudinal analyses reported.

Table 10

Risk of Bias Ratings: Cohort/Longitudinal Designs

Report	1	2	3	4	5	6	7	8	9	10	11	12	13	Overall Risk of Bias
Gomes (2019)	Yes	NA	Yes	Yes	yes	Yes	Yes	No	yes	yes	No	yes	yes	Moderate
Pryor (2016)	Yes	NA	Yes	Yes	Yes	Yes	Yes	Yes/No[1]	Yes	Yes	yes	Yes	Yes	Low
Stice (2001)	Yes	NA	No	Yes	Yes	yes	Yes	yes	unclear	Yes	yes	Yes	Yes	Low
Thompson (1995)	Yes	NA	No	No	No	Unclear	yes	no	Yes	Yes	No	Unclear	Yes	High
Vaughan (2010)	Yes	NA	Yes	Unclear	yes	yes	Yes	Yes/No[2]	Yes	Yes	yes	Yes	yes	Moderate
Wynne (2016)[3]	~~Yes~~	~~NA~~	~~yes~~	~~No~~	~~No~~	~~Unclear~~	~~Yes~~	~~no~~	~~Yes~~	~~Yes~~	~~No~~	~~yes~~	~~Yes~~	~~High~~
Xie (2010)	Yes	NA	Yes	yes	yes	Yes	yes	No	yes	Yes	no	unclear	yes	Moderate

Note: According to the JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies (Moola et al., 2020), modified for the current review, the item numbers map onto the following checklist questions: 1= Were the two groups similar and recruited from the same population?, 2= Were the exposures measured similarly to assign people to both exposed and unexposed groups?, 3= Was the exposure measured in a valid and reliable way?, 4= Were confounding factors identified?, 5= Were strategies to deal with confounding factors stated?, 6= Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?, 7= Were mediators measured in a valid and reliable way?, 8= Was temporal precedence of the exposure, mediator, and outcome established?, 9= Were the outcomes measured in a valid and reliable way?, 10= Was the follow up time reported and sufficient to be long enough for outcomes to occur?, 11= Was follow up complete, and if not, were the reasons to loss to follow up described and explored?, 12= Were strategies to address incomplete follow up utilized?, 13= Was appropriate statistical analysis used? ***Response Options***: (items 1-13) yes; no; unclear = could not accurately rate this item based on information contained in report (and in consultation with accompanying reports and/or correspondence from authors; NR = not reported; NA = not applicable to the current investigation. (Overall risk of bias rating) low risk, moderate risk, high risk.

[1] Study assessed both "body dissatisfaction" and "peer victimization" as mediators; temporal precedence was established for body dissatisfaction, but not for peer victimization.

[2] Data only from two time points (rather than optimal three required to establish temporal precedence). Authors attempted to establish temporal precedence with two waves of data using an assumption of stationarity, wherein the time 1 exposure predicted time 2 mediator (and outcome), and time 1 mediator predicted time 2 outcome (Vaughan & Halpern, 2010).

[3]Wynne et al. (2016) included both cross-sectional and longitudinal analyses. The cross-sectional dataset was more complete for outcomes of interest to the current review, and the report rated as reflecting a lower risk of bias (moderate) for cross-sectional outcomes than the longitudinal analyses (high risk). As such, only the cross-sectional data is presented.

Appendix J: Effects Included in Quantitative and Qualitative Syntheses

Table 11

Effects Included in Quantitative (Indirect and Total Effects) and Qualitative Syntheses

Author-Year (mediator)	**Overall Average Indirect Effect**	**Subgroup Analysis: Gender**		**Subgroup Analysis: Mediator Class**			**Subgroup Analysis: GAM**		**Subgroup Analysis: GAM x Sex**			
		F	*M*	*Cog*	*Soc*	*Beh*	*GAM*	*Non-GAM*	*GAM: F*	*GAM: M*	*Non-GAM: F*	*Non-GAM: M*
Allen-2006 (body dissatisfaction)	ITQ	x	x	ITQ	x	x	ITQ	x	x	x	x	x
Bang-2012 (teasing)	ITQ	x	x	x	ITQ	x	x	ITQ	x	x	x	x
Chaiton-2009 (body dissatisfaction)[1]	x	x	x	x	x	x	x	x	x	x	x	x
Chaiton-2009 (pressure to be thin)	IT	IT	IT	x	IT	x	IT	x	I	I	x	x
Chaiton-2009 (full model)	x	Q	Q	x	x	x	Q	x	Q	Q	x	x
Deepthi-2014 (bingeing)	Q	x	x	x	x	Q	Q	x	x	x	x	x

Author-Year (mediator)	**Overall Average Indirect Effect**	**Subgroup Analysis: Gender**		**Subgroup Analysis: Mediator Class**			**Subgroup Analysis: GAM**		**Subgroup Analysis: GAM x Sex**			
		F	*M*	*Cog*	*Soc*	*Beh*	*GAM*	*Non-GAM*	*GAM: F*	*GAM: M*	*Non-GAM: F*	*Non-GAM: M*
Ge-2001 (weight perception)[2]	x	x	x	x	x	x	x	x	x	x	x	x
Gomes-2019 (physical activity)[3]	Q	Q	Q	x	x	Q	x	Q	x	x	x	x
Gomes-2019 (diet quality)[3]	Q	Q	Q	x	x	Q	x	Q	x	x	x	x
Mond-2011 (body dissatisfaction: early adol)	ITQ	ITQ	ITQ	ITQ	x	x	ITQ	x	IQ	IQ	x	x
Mond-2011 (body dissatisfaction: late adol)[4]	Q	Q	Q	Q	x	x	Q	x	Q	Q	x	x
Needham-2005 (self-rated health)[3]	x	x	x	x	x	x	x	x	x	x	x	x
Needham-2005 (dieting)[2]	Q	Q	Q	x	x	Q	Q	x	Q	Q	x	x

Author-Year (mediator)	Overall Average Indirect Effect	Subgroup Analysis: Gender		Subgroup Analysis: Mediator Class			Subgroup Analysis: GAM		Subgroup Analysis: GAM x Sex			
		F	*M*	*Cog*	*Soc*	*Beh*	*GAM*	*Non-GAM*	*GAM: F*	*GAM: M*	*Non-GAM: F*	*Non-GAM: M*
Needham-2005 (dieting: lower grades)[2]	Q	x	x	x	x	Q	Q	x	x	x	x	x
Needham-2005 (dieting: upper grades)[2]	Q	x	x	x	x	Q	Q	x	x	x	x	x
Pryor-2016 (body dissatisfaction early onset overweight)[1]	Q	Q	Q	Q	Q	x	Q	x	Q	Q	x	x
Pryor-2016 (body dissatisfaction: late onset overweight)[1]	Q	Q	Q	Q	Q	x	Q	x	Q	Q	x	x
Pryor-2016 (teasing: early onset overweight)	IT	Q	Q	x	IT	x	x	ITQ	x	x	x	x
Pryor-2016 (teasing: late onset overweight)	IT	Q	Q	x	IT	x	x	ITQ	x	x	x	x

Author-Year (mediator)	Overall Average Indirect Effect	Subgroup Analysis: Gender		Subgroup Analysis: Mediator Class			Subgroup Analysis: GAM		Subgroup Analysis: GAM x Sex			
		F	*M*	*Cog*	*Soc*	*Beh*	*GAM*	*Non-GAM*	*GAM: F*	*GAM: M*	*Non-GAM: F*	*Non-GAM: M*
Santos-2007 (body dissatisfaction)	IT	ITQ	ITQ	IT	x	x	IT	x	I	I	x	x
Santos-2007 (full model)	x	Q	Q	x	x	x	Q	x	Q	Q	x	x
Stice-2001 (body dissatisfaction)	I	I	x	I	x	x	I	x	I	x	x	x
Stice-2001 (thin ideal internalization)[5]	x	x	x	x	x	x	x	x	x	x	x	x
Stice-2001 (pressure to be thin)[5]	x	x	x	x	x	x	x	x	x	x	x	x
Stice-2001 (dieting)[5]	x	x	x	x	x	x	x	x	x	x	x	x
Stice-2001 (eating disorder symptoms)[5]	x	x	x	x	x	x	x	x	x	x	x	x

Author-Year (mediator)	Overall Average Indirect Effect	Subgroup Analysis: Gender		Subgroup Analysis: Mediator Class			Subgroup Analysis: GAM		Subgroup Analysis: GAM x Sex			
		F	*M*	*Cog*	*Soc*	*Beh*	*GAM*	*Non-GAM*	*GAM: F*	*GAM: M*	*Non-GAM: F*	*Non-GAM: M*
Stice-2001 (full model)[5]	x	Q	x	x	x	x	Q	x	Q	x	x	x
terBogt-2006 (weight perception)	ITQ	Q	Q	ITQ	x	x	x	ITQ	x	x	x	x
Thompson-1995 (body dissatisfaction)[1]	x	x	x	x	x	x	x	x	x	x	x	x
Thompson-1995 (appearance dissatisfaction) [1]	x	x	x	x	x	x	x	x	x	x	x	x
Thompson-1995 (teasing)	I	x	x	x	I	x	x	I	x	x	x	x
Ting-2012 (weight perception)[3,5]	Q	x	x	Q	x	x	x	Q	x	x	x	x
Ting-2012 (dieting)[3,5]	Q	x	x	x	x	Q	Q	x	x	x	x	x
Ting-2012 (weight concern)[3,5]	Q	x	x	Q	x	x	x	Q	x	x	x	x

Author-Year (mediator)	Overall Average Indirect Effect	Subgroup Analysis: Gender		Subgroup Analysis: Mediator Class			Subgroup Analysis: GAM		Subgroup Analysis: GAM x Sex			
		F	*M*	*Cog*	*Soc*	*Beh*	*GAM*	*Non-GAM*	*GAM: F*	*GAM: M*	*Non-GAM: F*	*Non-GAM: M*
Ting-2012 (full model)[3,5]	x	x	x	x	x	x	Q	x	x	x	x	x
Vaughan-2010 (weight perception)[1]	x	x	x	x	x	x	x	x	x	x	x	x
Vaughan-2010 (dieting)	IT	IT	IT	x	x	IT	IT	x	I	I	x	x
Vaughan-2010 (full model)	x	Q	Q	x	x	x	Q	x	Q	Q	x	x
Wynne-2016 (body dissatisfaction cross-sectional)	IT	x	x	IT	x	x	IT	x	x	x	x	x
Wynne-2016 (body dissatisfaction longitudinal)[3]	x	x	x	x	x	x	x	x	x	x	x	x
Xie-2005 (teasing)	IT	ITQ	ITQ	x	ITQ	x	x	ITQ	x	x	I	I

Author-Year (mediator)	Overall Average Indirect Effect	Subgroup Analysis: Gender		Subgroup Analysis: Mediator Class			Subgroup Analysis: GAM		Subgroup Analysis: GAM x Sex			
		F	*M*	*Cog*	*Soc*	*Beh*	*GAM*	*Non-GAM*	*GAM: F*	*GAM: M*	*Non-GAM: F*	*Non-GAM: M*
Xie-2005 (perceived availability of social support) [3]	x	x	x	x	Q	x	x	Q	x	x	x	x
Xie-2010 (body dissatisfaction)	ITQ	ITQ	ITQ	ITQ	x	x	ITQ	x	IQ	IQ	x	x
Yen-2014 (teasing/ passive bullying victim)	I	IQ	IQ	x	IQ	x	x	IQ	x	x	I	I
Yen-2014 (active bullying victim)[1]	x	Q	Q	x	Q	x	x	Q	x	x	x	x
Yen-2014 (passive bullying perpetration)[1]	Q	Q	Q	x	Q	Q	x	Q	x	x	x	x
Yen-2014 (active bullying perpetration)[1]	Q	x	x	x	Q	Q	x	Q	x	x	x	x

Note. Subgroup analyses for which only qualitative synthesis was conducted (i.e., moderation by developmental stage, culture, GAM x developmental stage, GAM x culture, and individual mediator effects) are not represented. **Response options:** I = included in

quantitative synthesis of indirect effects; T = included in quantitative synthesis of total effects; Q = included in qualitative synthesis.
Abbreviations: F = female; M = male; Cog = cognitive variables; Soc = social variables; Beh = behavioural variables; GAM = variable is included in the *gender additive model of depression* (GAM; Stice & Bearman, 2001); Non-GAM = variable is not included in the GAM; GAM: F = variable is included in the GAM and reported effect is for females; GAM:M = variable is included in the GAM and the reported effect is for males; Non-GAM:F = variable is not included in the GAM and the reported effect is for females; Non-GAM:M = variable is not included in the GAM and the reported effect is for males
[1] Report presented effects for multiple mediators; only one mediator was selected for inclusion in meta-analysis to avoid non-independence of effects.
[2] Effect was excluded from meta-analysis to avoid non-independence of effects; data originated from the same large, population-based study (AddHealth) represented in Vaughan & Halpern (2010)
[3] Unable to convert effect estimates to usable effect size
[4] Effect was excluded from meta-analysis to avoid non-independence of effects; overlap with the early adolescent subsample
[5] Insufficient data reported