An examination of body esteem and health outcomes in community samples of youth and youth in pediatric weight management

by

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Abstract

Existing literature is conflicting about the association between body mass index (BMI), body image, quality of life, and disordered eating in samples of community youth, and youth in pediatric weight management programs. This thesis explored these associations through two studies. Study 1 was a meta-analysis examining the association between BMI and health outcomes and Study 2 was a longitudinal study of the bidirectional associations between these variables in a sample of youth in a weight management program. Meta-analytic results indicated that BMI was significantly associated with body image (r = -0.41; N = 57; p <.001), disordered eating (r = 0.14; N = 46; p <.001), and quality of life (r = -0.22; N = 21; p <.001). However, there were significant sex and construct differences, such that for most body image subgroups the association between BMI and body image was significantly larger for female samples. Additionally, studies that used figure rating scales compared to Likert assessments of body image had stronger associations with BMI and no sex differences. In Study 2, 209 youth (111 female; ages 4-18) were included in a retrospective chart review from a pediatric weight management program. Latent growth modelling was used to examine univariate growth trajectories of each variable and the bidirectional associations between body esteem, disordered eating, quality of life, and BMI over time. It was hypothesized that: 1) higher initial body esteem would be associated with lower disordered eating and higher quality of life at baseline, 2) higher initial body esteem would be associated with more favourable changes in disordered eating and quality of life over time, and 3) increases in body esteem would be associated with decreases in disordered eating and increases in quality of life over time. Results indicated that baseline body esteem was associated with baseline emotional

eating and quality of life, however body esteem was relatively stable over time and was not associated with changes in quality of life, or disordered eating over time. These results have implications for our understanding of the stability of body esteem over time, body image measurement and terminology, and its role in pediatric weight management programs.

Keywords: body esteem; body mass index; weight status; body image; quality of life; disordered eating; youth; obesity;

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An examination of body esteem and health outcomes in community samples of youth and youth in pediatric weight management

Obesity is the most common chronic condition among adolescents followed by asthma and eating disorders (Golden et al., 2016). Obesity and eating disorders are major public health concerns for youth in Canada and internationally (Golden et al., 2003; Neumark-Sztainer & Hannan, 2000; Sanchez-Carracedo et al., 2012; Stice et al., 2009), and are associated with negative psychological, physical, and social consequences (Goldschmidt et al., 2008). There are a number of shared risk factors among people with eating disorders and obesity including: poor body image, disordered eating behaviour, and lower quality of life (Markey & Markey, 2005; Neumark-Sztainer, Wall, Guo, et al., 2006). In particular, low body satisfaction and unhealthy weight control behaviours have been associated with weight gain and obesity in some individuals (Neumark-Sztainer, Wall, Guo, et al., 2006), and eating disorders in others (Le Grange & Loeb, 2007). Weight-related illnesses are often linked to poorer academic, social, psychological, and physical outcomes. Weight-related problems include obesity, eating disorders (i.e., anorexia, bulimia, and binge eating), and disordered eating (e.g., external, emotional, and restrained eating; Neumark-Sztainer et al., 2007). Research suggests that weight-related problems can occur simultaneously, increase in severity, and lead to the onset of a different weight-related problem over time (Croll et al., 2002; Eisenberg & Neumark-Sztainer, 2010; Kass et al., 2015; Neumark-Sztainer, Wall, Guo, et al., 2006).

Kass and colleagues (2015) examined the relationship between weight status and rates of eating disorder risk and eating disorder pathology in a sample of 1,529 college students. This sample included students who were classified as underweight (8%), normal

weight (77%), and overweight or obese (15%). Results indicated that participants who had overweight[1] or obesity were more likely to report higher eating disorder pathology and weight changes than students in lower weight categories (Kass et al., 2015). Fifty-eight percent of students with overweight and obesity were considered at high risk for developing an eating disorder, compared to 34% with average weight, and 25% of underweight students. Thus, obesity and eating disorders often co-occur, necessitating the need to integrate treatment programs for weight-related problems in order to reduce shared risk factors and improve shared protective factors.

Shared risk factors for obesity and eating disorders may include dieting, weight-related talk, and weight-teasing (Golden et al., 2016). Shared protective factors might include having a healthy positive body image and engaging in family meals (Golden et al. 2016). A main focus of the current research is to examine the impact of body image on health-related outcomes (i.e., body mass index, quality of life, eating behaviours) in youth with obesity who are part of a weight management program. This research will provide insight into the long-term association between body image, eating behaviours, quality of life, and BMI in children and youth living with obesity.

Research indicates a consistent association between eating behaviours and weight (Neumark-Sztainer & Hannan, 2000). More specifically, longitudinal studies have demonstrated a strong relationship between dieting behaviour, increased weight, and binge eating in youth (Neumark-Sztainer et al., 2007; Neumark-Sztainer & Hannan, 2000). Dieting has also been identified as a precursor to eating disorders, and the most significant predictor of developing an eating disorder (Patton et al., 1999). These findings

[1] Using terms such as overweight and obese to describe youth with higher weight may no longer be appropriate as research is moving toward less biased terminology (e.g., higher average weight).

suggest that restrictive dieting is harmful for youth with obesity and youth with eating disorders as it can perpetuate other weight-related illnesses.

Another risk factor for both eating disorders and obesity is weight-related talk (Berge et al., 2014; Loth et al., 2009; Neumark-Sztainer et al., 2007). Weight-related talk includes comments made by family or friends about their own weight or about a child's/individual's weight (even well intended comments). A longitudinal study of adolescents found that weight-related talk was associated with overweight or obesity five-years later (Neumark-Sztainer et al., 2007). In addition, frequent weight-related talk among family and friends has been associated with eating disorders in youth (Loth et al., 2009). For example, in semi-structured interviews with individuals receiving treatment for eating disorders, Loth and colleagues (2009) found that a decrease in weight-related talk appeared as a common theme suggested by participants to reduce eating disorder behaviours. Specifically, participants recommended that the following behaviours should be avoided within the family unit: (a) parents talking about their own weight or body, (b) parents talking about their child's weight or body, (c) general discussion of weight or figure with others and, (d) weight-related teasing.

Additional research has demonstrated that weight-teasing from peers and parents is associated with the development of binge eating, and extreme weight control behaviours in youth (Neumark-Sztainer et al., 2007). It appears that the negative impact of dieting, weight-related talk, and weight-teasing on weight-related problems is substantial and a potential area for intervention among parents and youth. It is possible that a good first step in reducing obesity and disordered eating would be to target the shared protective factors of weight-related problems.

The shared protective factors that have been identified for obesity and eating disorders are family meals and having a 'healthy' body image. Researchers have found that regular family meals are associated with improved dietary intake, as they provide opportunities to model balanced eating behaviours for children (Fulkerson, 2008). In addition, family meals promote more consumption of fruits and vegetables, grains, calcium, and fibre, and less consumption of carbonated beverages among youth (Neumark-Sztainer, Hannan et al., 2003), and have been shown to be a protective factor against eating disorders for girls (Neumark-Sztainer, Wall, et al., 2004).

Approximately half of teenage girls and one-quarter of teenage boys are dissatisfied with their bodies, and these numbers are larger in teens living with overweight or obesity (Neumark-Sztainer, Croll, et al., 2002). Body dissatisfaction is a risk factor for weight-related problems such as eating disorders, obesity, disordered eating, dieting, binge eating, unhealthy weight control behaviours, and reduced physical activity (Neumark-Sztainer, Paxton, et al., 2006). However, researchers have found that youth who report a more positive body image report more healthy eating behaviours and physical activity messages from parents and peers, and less personal weight-related comments and behaviours from parents and peers (Kelly et al., 2004). Specifically, high school girls with high body satisfaction were less likely to weigh themselves, use unhealthy weight control behaviours, have peers who engaged in dieting behaviour, and were more likely to have mothers who encouraged health behaviours not dieting. It is possible that having a positive body image is a protective factor against some of the negative consequences associated with obesity and eating disorders (Golden et al., 2016).

Research suggests that prevention programs for eating disorders and obesity should be combined and include integrative messaging around balanced eating, mental health, and positive body image (Ciao et al., 2014; Neumark-Sztainer, Wall, et al., 2006). In contrast to earlier programs that have focused solely on weight or body mass index (BMI) as desired outcomes of intervention programs, current treatment of obesity and eating disorders is more likely to include family involvement, focus on healthy lifestyle practices that are sustainable, and facilitate having a positive body image.

Since obesity is the leading chronic condition among youth, the present thesis included a study that focused on children and youth with obesity who were part of a hospital-based weight management program that addresses some of the shared risk and protective factors that have been identified for weight-related problems.

The purpose of the present thesis was to examine the role of body esteem (i.e., how much an individual likes and feels good about their weight and/or appearance) in a sample of children and youth who were participating in a pediatric weight management program. To date, there have been few studies that have examined body esteem longitudinally in children; and no study known to the author that has thoroughly examined body esteem in a clinical sample of youth with severe obesity over time in tertiary care. To fully understand the role of body image in youth as it relates to weight, two studies were conducted. For Study 1, I conducted a meta-analysis that examined the association between BMI and body image[2], disordered eating, and quality of life in

[2] To be discussed below: Body image (i.e., one's psychological experiences of the appearance and functioning of one's body; Cash & Pruzinsky, 1990) has been operationally defined in many different ways. The different definitions were explored in the current meta-analysis. For Study 2, body image was defined as body esteem (i.e., a person's self-evaluations of their body or appearance, specifically in relation to their own feelings about their appearance and weight; Mendelson & White, 1985)

community samples of children and youth; in Study 2, I examined the role of body esteem (i.e., how an individual feels about their appearance) on treatment outcomes (i.e., BMI, disordered eating, quality of life) at a multidisciplinary weight management program, designed to help manage childhood obesity, incorporating the role of body image into its messaging. In the pages that follow, I will review the childhood obesity literature, discussing the prevalence and etiology of this disorder. This will be followed by a review of the literature on body image, and its relevance in the treatment of obesity and disordered eating behaviour, and the impact that poor body image and obesity have on quality of life.

Obesity

Obesity is a chronic condition that affects approximately 27% of adults and 12% of children in Canada and worldwide (Ng et al., 2014; Statistics Canada, 2019; Statistics Canada, 2015). Obesity is characterized by excess body fat that can negatively impact someone's physical, mental, or metabolic health (Obesity Canada, n.d.; Public Health Agency of Canada [PHAC], 2011). A number of environmental, genetic, and emotional factors, physical and psychological comorbidities, and various medications (e.g., antipsychotics) can contribute to obesity (Singh et al., 2008). Current statistics show that one in four adults and one in seven youth in Canada have obesity (Rao et al., 2016). These numbers far surpass the rates of diabetes, arthritis, heart disease, or cancer in Canada (Obesity Canada, n.d). Traditionally, clinical recommendations for assessing and managing paediatric obesity have relied on anthropometric measures, such as body mass index (BMI), BMI percentile and/or BMI z-score, to monitor health risks and determine weight management success. However, anthropometric measures do not always

accurately identify children with obesity-related health risks or comorbidities. For Study 2, the World Health Organization's definition of obesity was used for eligibility into the weight management program - defined as a BMI at or above the 95th percentile for children and teens of the same age and sex (WHO, 2020) with the addition of having one or more metabolic co-morbidity. The weight management program used the Edmonton Obesity Staging System for Pediatrics, (EOSS-P), adapted from the adult-oriented EOSS, to stratify patients according to severity of obesity-related comorbidities and barriers to weight management into four graded categories within four main health domains: metabolic, mechanical, mental health and social milieu (the 4Ms; Hadjiyannakis et al., 2016).

There are a number of psychological, physical, mechanical, metabolic, and monetary health-related consequences of obesity (Obesity Canada, n.d.; Singh et al., 2008). For example, people with obesity can suffer from depression, anxiety, negative self-esteem, body dissatisfaction, and disordered eating or eating disorders. In addition, people with obesity may experience mechanical health-related consequences such as sleep apnea, heartburn, osteoarthritis, planter fasciitis, urinary or fecal incontinence, and skin fold infections (Obesity Canada, n.d; Singh et al., 2008). Having obesity can increase a person's risk for developing type 2 diabetes, hypertension, high cholesterol, gout, fatty liver disease, infertility, and cancer. Lastly, there are monetary consequences associated with having obesity including, lower education, lower rates of employment, less professional development opportunities, increased cost of living (e.g., mobility aids), and cost of weight loss programs (Obesity Canada, n.d). It is evident that people with obesity are experiencing several adverse health-related consequences that decrease their

quality of life. Therefore, it is important to examine this group more closely to determine the impact of known risk and protective factors that could influence their well-being.

Obesity is a complex disease that is exacerbated by weight stigma (Lynagh et al., 2015; Puhl et al., 2018). While there are a number of factors that contribute to obesity, experiencing weight stigma is harmful for physical and mental health outcomes (Lynagh et al., 2015). Weight stigma consists of negative beliefs and experiences about a person based on their weight (Puhl et al., 2018). This can include weight teasing and discrimination based on weight (Puhl et al., 2018). Among children, those with high BMI are more likely to experience verbal and physical victimization in school than children with lower BMI (Pont et al., 2017). Weight stigma is prominent in healthcare, education, employment, media, and family settings and internalizing of weight bias has been associated with poor overall health (Jeon et al., 2018; Lydecker et al., 2017; Phelan et al., 2014; Tomiyama et al., 2015). A 15-year longitudinal study found that experiences of weight stigma during adolescence were associated with higher BMI, binge eating, and low self-esteem in adulthood (Puhl, Armstrong, et al., 2017). Experiences of weight stigma have also been associated with poor body image and healthcare stress and avoidance (Mensinger et al., 2018). The use of weight-based terminology (e.g., obese) has been associated with sadness and embarrassment in adolescents (Hunger & Tomiyama, 2014; Puhl, Himmelstein, et al., 2017). This suggests that how people talk about weight and experiences of weight stigma can be detrimental to mental health and the quality of life of youth with higher average weight.

It is possible that experiences of weight stigma explain the relationship between BMI and negative health outcomes. A study of adults found that perceived weight stigma

mediated the association between BMI and self-reported health (Hunger & Major, 2015). A meta-analysis found a medium negative association between weight stigma and mental health and that this association was stronger in samples with higher BMI (Emmer et al., 2020). While weight stigma is not a focus of the current study, it is important to acknowledge the implications of these types of stigmatizing experiences and feelings on physical and mental health as they are likely to diminish the positive effects of Health at Every Size weight management efforts.

While there are adults and children living with obesity, children with obesity tend to experience more adverse impacts of this disease as it often chronic and in the most extreme cases is associated with significant medical morbidity (Golden et al., 2016). Children with obesity experience a number of health and social challenges such as, disordered eating, relational and physical aggression, lower body and self-esteem, and poor quality of life (Puhl & Heuer, 2010; Singh et al., 2008). There are significant risk factors that can perpetuate childhood obesity, including extreme weight control practices (e.g., restrictive eating), binge eating behaviours, weight discrimination, body dissatisfaction, weight-teasing, and media exposure (Haines et al., 2007; Levine et al., 1994; Puhl & Heuer, 2010; Stice, Agras, et al., 1999). However, there are also protective factors including, an accepting and supportive home environment, regular family meals, absence of negative weight comments, incorporating voluntary physical activity into daily life, and having schools and physicians encourage positive self-talk and positive body image (Neumark-Sztainer, 2011; Neumark-Sztainer et al., 2007). Of particular interest to the present researcher is the role of body image, and how feelings of body

esteem can enhance the effectiveness of treatment programs and quality of life for children with obesity.

Body Image

In the past, body image research has been dominated by clinical data pertaining to eating disorders, particularly in women. Today, the area of body image extends not only to sociocultural areas of research but now, health fields, and behavioural sciences. For example, there is research examining the body image of burn victims, people with cancer, or skin diseases, and anything else that can alter or impact how we think or feel about our bodies and appearance, such as obesity. Body image research is particularly diverse as it has explored a variety of illnesses related to body function and appearance that can impact a person's body image and well-being (Cash, 2004). The impact that body image has on quality of life is vast (Cash, 2004), and it has been linked to disordered eating, low self-esteem, and depression, particularly in youth with obesity (Smolak & Thompson, 2009; Neumark-Sztainer et al., 2006).

Terminology

Body image is a multidimensional construct with affective, evaluative, cognitive, and behavioural mechanisms (Muth & Cash, 1997). Body image can be examined on a continuum that can range from a healthy body image (i.e., positive), to an unhealthy (i.e., negative) body image. The construct of body image encompasses behaviours and thoughts that people engage in, such as: evaluating one's body, the degree of investment in one's appearance, and one's internalization of body ideals that are shaped by the social and cultural environment (Cash, 2004; Cash & Smolak, 2011).

The most common area of body image that has been studied is a person's evaluation of their own body or appearance. This includes assessing their body or appearance, comparing it to sociocultural ideals, and having the cognitive skills to make this comparison (Thompson & Stice, 2001). For example, some people internalize media body ideals and believe that there is only one type of body or appearance that is beautiful (e.g., thin, with large breasts for women; lean, tall, and muscular for men); while other people may challenge these ideals and promote the beauty of body diversity (i.e., every body is beautiful). Body image also includes a person's investment in his or her image, in particular, the degree to which a person's cognitions and behaviours indicate the importance of their appearance in evaluating their sense of self (Thompson & Stice, 2001). For example, some people with high body image investment may engage in excessive exercise to combat food intake and to feel more secure in their appearance.

Body esteem, body image, and body (dis)satisfaction are all terms that are used in the literature to talk about an individual's feelings about their own body and appearance. These terms describe how positively or negatively an individual feels about their body. However, it is important to note that the absence of a negative body image is not the same as having a positive body image or body esteem. Body image is not only a person's subjective evaluation of his or her own physical appearance (Thompson et al., 1999), but is also the psychological experience of embodiment (Cash & Pruzinsky, 1990). It includes thoughts, experiences, feelings, and behaviours that are focused around one's body. This evaluation of a person's own appearance can lead to body dissatisfaction (Thompson, et al., 1999).

Body dissatisfaction is when someone has a negative view of their body or appearance (Cash & Smolak, 2011; Grogan, 2016). Body esteem refers to a person's self-evaluations of their body or appearance, specifically in relation to their own feelings about their appearance and weight, and how a person perceives that other people evaluate their appearance (Mendelson & White, 1985). To avoid confusion, the present study will be referring to the "body image" of youth with obesity, as the term "body image," encompasses all of the terms used to speak about how people feel about and evaluate their bodies (e.g., body (dis)satisfaction, body esteem).

It is important to note that Study 2 of the present thesis measured the construct of body esteem, more specifically, how positively an individual feels about his or her appearance and weight. The body esteem scale used in Study 2 (Mendelson et al., 2001) assesses the degree to which individuals like their weight and appearance. The two subscales used, focus on weight esteem (e.g., "I really like how much I weigh") and appearance esteem (e.g., "I like what I look like in pictures"). Past research has found that weight esteem is negatively related to increased weight, and appearance esteem has been positively associated with self-esteem (Mendelson et al., 2001). Thus, the measure of body esteem used in the current research is consistent with research on body image, weight, and self-esteem (e.g., youth who have higher weight, are less likely to report weight esteem; youth who have high self-esteem are more likely to report appearance esteem). However, throughout the introduction, the original terminology (e.g., body image, body (dis)satisfaction, body esteem) from previous research will be used, as it all falls within the more general category of body image.

Positive psychology and the biopsychosocial model

Much of the current literature on body image is related to eating disorders such as anorexia nervosa and bulimia nervosa. This research often examines negative or low body image, as it is a major contributor to eating disorder development. However, the present thesis focused on the importance of positive body image (e.g., “I’m pretty happy about the way I look”), for youth living with obesity. This will be a first step in examining positive body image as little research has been done on the impact of body esteem and its influence on eating behaviours and quality of life in youth with severe complex obesity.

A positive psychology perspective is embedded in the mindset of health promotion (Tylka & Augustus-Horvath, 2011). Early positive psychology scholars argued that getting rid of negative feelings or predispositions is not enough. It is also important to teach positive thinking to improve mental health (Wood-Barcalow et al., 2010). Therefore, it is important when measuring positive body image that one is not just measuring body dissatisfaction and interpreting low levels of body dissatisfaction as evidence of positive body esteem but rather examining positively framed messages about the body. The present thesis used a measure of body esteem that includes both positively and negatively framed messages about one’s appearance and weight (Mendelson et al., 2001). This allowed for an examination of a more positive perception of one’s appearance and weight.

Characteristics of positive body image include: body appreciation, body acceptance, broadly conceptualizing beauty, media literacy, unconditional acceptance from others, surrounding oneself with people with positive body images, and listening to and taking care of the body (Frisen & Holmqvist, 2010; Wood-Barcalow et al., 2010).

For example, body appreciation, acceptance, and love occur when a person feels good in their body, has accepted their body as it is, and appreciates the functionality of their body. Further having a positive body image includes broadly conceptualizing beauty, which involves accepting different body types and recognizing different figures and appearances as beautiful (Wood-Barcalow et al., 2010).

Positive body image falls under the umbrella term of *body image* but moves the focus from negative and dissatisfied body-related feelings to more general feelings of liking and appreciating one's appearance and body, and recognizing that *beauty* is not defined as looking one specific way. A qualitative study of adolescents with high body satisfaction scores attempted to further understand the nuances of positive body image and found that general feelings of 'looking average,' having a 'functional view' of the body, and acceptance of 'imperfections' were key themes that youth indicated as characteristics of their positive body image (Frisen & Holmqvist, 2010). People with a positive body image are often media literate, indicating that they are aware of the skewed perceptions that are projected in the media and they realize that beauty is not looking one specific way (e.g., thin or muscular). It is important to note that anyone can have positive body image regardless of shape or size. Feeling good about one's body and appearance is not reserved for those who are thin and stereotypically beautiful.

This perspective is complementary to the present thesis as this is a focus of the weight management program that was examined in Study 2. Positive body image is a protective schema, especially for children with obesity (Tylka & Augustus-Horvath, 2011). There has been little research examining how having a positive body image

impacts youth with obesity. However, some intervention studies of adults with obesity have found promising results.

Past treatment for body dissatisfaction has focused on weight loss for improving body image; however, this was not effective since most people end up regaining the weight they lost (Schwartz & Brownell, 2004). Therefore, it is important to make people feel good in the body that they have (Schwartz & Brownell, 2004). In 1995, Rosen and colleagues provided cognitive behavioural therapy (CBT) related to body dissatisfaction for women with obesity. Researchers found that there were improvements in body image distress, self-esteem, and a reduction in binge eating behaviour (Rosen et al., 1995). This suggests that improving body image may be advantageous for improving self-esteem and reducing disordered eating behaviours in women with obesity. Importantly, most participants in the body image intervention did not experience weight change, and those who did, did not report a significant association between their weight change and positive mental and physical health outcomes.

Another study of adults with obesity compared a non-diet wellness program (focusing on positive body image) and a standard CBT for weight loss program (focusing on diet and exercise), and found that both groups reported increases in body image after treatment (Bacon et al., 2002). However, the weight loss group attributed their improved body image to losing weight, which is problematic since weight loss is difficult to sustain. Research from long-term follow-up studies shows that most people regain the weight that is lost during treatment regardless of diet and physical activity maintenance (Langeveld et al., 2015; Mann et al., 2007; Miller, 1999). Therefore, learning to accept

one's body as it is, may be the best treatment for positive health-related outcomes for people living at higher weights.

Positive body image promotes loving the self and body regardless of idealized images, and appreciating the functionality and unique aspects of different bodies (Frisen & Holmqvist, 2010; Wood-Barcalow et al., 2010). Furthermore, positive body image encourages internalizing positive body comments and feelings, and rejecting the negative. Therefore, the idea of positive body image may be a larger concept than simply liking the way one looks. It is proposed that body esteem (liking and feeling good about one's appearance and weight) is only part of the process to achieve an overall positive body image. It is possible that examining body esteem in youth with obesity is a good place to start exploring the benefits of positive body image on health behaviours and quality of life.

The biopsychosocial model encompasses the positivity psychology perspective while focusing on psychological, physiological, and environmental influences on health. Current health research suggests that biopsychosocial factors should always be examined when studying the intricacies of a chronic condition (Berk, 2010; Galea et al., 2010; Hales & Barker, 2001; Ritz et al., 2013). Engel first suggested the idea of a holistic model to examine health from a biological, psychological, and social lens (Engel, 1977). Engel developed the biopsychosocial model in response to his criticism of the biomedical focus of health research (Engel, 1977). His movement was fuelled by the lack of humanism and compassion in the traditional medical model. Engel's critique included the impact of psychosocial variables on illness, the influence of the patient-clinician perspective related

to program adherence, the separation of body and mind, and medical neglect of human suffering.

The biopsychosocial model is relevant in body image and obesity research. For example, obesity is influenced by a number of factors including genetics, physical comorbidities, mental health, nutrition, physical activity, sleep, and family dynamics (Singh et al., 2008). To clarify, there is no singular "cause" of obesity. Rather, there are multiple interacting variables or risk factors that contribute to obesity. This also rings true for body image development. Specifically, positive body image development can be fostered through positive social relationships, participation in physical activity, feelings of autonomy, lack of media internalization, and self-compassion. Accepting a biopsychosocial model of body image and obesity can help manage unrealistic expectations, reduce biases related to the causes of obesity, and further broaden the scope of health research to allow clinicians, researchers, and the public to apply a "whole person" approach to health. Therefore, the present thesis has embraced both a positive psychology and biopsychosocial perspective to examine the impact of body image on health outcomes in youth with obesity.

Age and sex differences in body image

Children begin comparing themselves to other children around age four (Cash & Smolak, 2011). By the age of eight, children are able to compare themselves to other people in four main areas including academic competence, social competence, physical/athletic skills, and physical appearance (Cash & Smolak, 2011). The cognitive ability to compare oneself to others is related to decreases in children's self-esteem around this age. Children begin to understand that some of their peers run faster than they

do, for example, decreasing their own perceived physical competence, and in some cases, children will now see themselves as larger than their peers, and thus, become less satisfied with their bodies. Social comparison is the most consistent risk factor for body dissatisfaction in children (Cash & Smolak, 2011). Children with obesity report being unhappy with their bodies as early as age six (Cash & Smolak, 2011). This is also the age that children begin to develop anti-fat biases, and these attitudes strengthen through elementary, middle, and high school (Musher-Eizenman et al., 2003).

Foundations for the development of a healthy body image are thus laid in childhood. Research indicates that children at five years old have internalized weight biases against people living with overweight and obesity (Musher-Eizenman, et al., 2003). Even three-year-old children might be aware that these cultural ideals exist (Musher-Eizenman et al., 2003). The research regarding the body image of young children is extensive. Dion and colleagues (2016) found that 57% of 9-14 year old children were unsatisfied with their body shape. Of these youth, 50% of girls and 36% of boys wanted a thinner body, while 21% of boys and 7% of girls wanted a larger body. Similarly, in a study of eight-to-ten year-old children, Wood and colleagues (1996) found that 55% of girls and 35% of boys were dissatisfied with their weight (Wood et al., 1996). This is problematic because body dissatisfaction increases into middle school and even more so into high school indicating that the percentage of youth with poor body image will be even larger in late adolescence (Groesz et al., 2002). In addition, body dissatisfaction in adolescence has been linked to a number of negative outcomes such as disordered eating and depression (Stice & Shaw, 2002).

In a study of 141 children (8-11 years old), Phares and colleagues (2004), examined the relationship between sex and body image development. Researchers found that girls reported greater body image and weight concerns, higher drive for thinness, and more family history of eating concerns than boys. In addition, more girls (61%) reported wanting to lose weight than boys (35.9%). However, there were no sex differences in body dissatisfaction. It is not surprising that girls reported a greater drive for thinness, as it is a beauty-ideal that is highly associated with females. It is possible that these results would be different if they had examined drive for muscularity as well. Further, results from correlational analyses revealed that girls' body dissatisfaction, bulimic tendencies, and drive for thinness were related to more depressive symptoms, lower global self-worth, greater family history of eating concerns, peer influence on eating concerns, and perceptions of teasing (Phares et al., 2004). Boys' body dissatisfaction was related to increased depressive symptoms, lower self-worth, greater family history of eating concerns, peer influence on eating concerns, and perceptions of teasing (Phares et al., 2004). Clearly, there are a number of adverse consequences for children who develop body dissatisfaction at a young age and these tend to become worse into adolescence.

Puberty has a large impact on body image for both boys and girls (Cash & Smolak, 2011). It is one of the most rapid and diverse times of change for development and has a significant influence on body composition (e.g., weight, height, shape; Cash & Smolak, 2011). This can be a challenging time for youth as their bodies may be changing at a different pace than their peers, and in ways that are undesirable based on sociocultural ideals. During puberty, girls have an increase in body fat (e.g., breasts and hips), additional body hair, acne, and fluctuating hormones. Thus, their bodies might be

moving further away from the thin physique that society has idealized for women. In particular, girls who mature earlier than their peers are more likely to gain more weight during puberty, which often leads to a greater drive for thinness (Lee et al., 2007). The internalization of thin ideals, placing a high value on appearance and body shape, and comparing oneself with others can lead to low self-esteem, and depression in girls (Dittmar & Howard, 2004). It is possible that early maturing girls are at a higher risk for body dissatisfaction.

Body image research has focused less on the patterns of boys and puberty. Biological influences on adolescent boys' body image center around the onset of puberty. For boys, early puberty is often a positive experience because it is representative of them becoming a 'man,' and comes with added muscle, and strength which are often their 'ideal' physical changes (Cash & Smolak, 2011). Late onset of puberty tends to be more of an issue for adolescent boys, and is associated with lower popularity, less social competence, lower school achievement, more conflict with their parents, and higher use of supplements to change their bodies (Cash & Smolak, 2011). Individual risk factors for low body esteem among adolescent boys include low self-esteem, higher negative mood, more perfectionistic tendencies, poor peer relationships, and use of drugs and alcohol (Cash & Smolak, 2011).

These findings are problematic because if youth acquire a negative body image during puberty, it is likely that it will worsen into adolescence. It is clear that both children and youth are impacted by their body image. The drive for thinness (for girls) and muscularity (for boys) is concerning as negative body image has been associated with adverse consequences for youth including disordered eating (Makinen et al., 2012),

and lower quality of life (Cash and Smolak, 2011). Therefore, it is critical that researchers examine body image development throughout childhood and adolescence to determine ways to reduce the negative impact of poor body image on physical and mental health. One potential risk factor for poor body image development in youth is having a higher BMI (Loth et al., 2015).

BMI and Body Image

The strength of the association between body image and body mass index (BMI) is unclear. BMI is an age and sex specific value that is used to quantify a person's body fat or health. BMI is calculated by dividing a person's weight (in kilograms) by their height (in meters squared). To determine if an individual is at a "healthy" weight, the Centre for Disease Control and Prevention has provided cut-off values to quantify underweight (child: BMI < 5th percentile; adult: BMI < 18.5), average weight (child: BMI in the 5th to 85th percentile; adult: BMI between 18.5 and 25), overweight (child: BMI in the 85th to 95th percentile; adult: BMI between 25 and 30), and obesity (child: BMI > 95th percentile; adult: BMI >30). Historically, health professionals and insurance companies have been quantifying the health and life expectancies of people by some metric of height and weight (Nuttall, 2015). However, the term BMI was not coined until 1972 (Keys et al., 1972) and was not widely adopted until 1995 (World Health Organization [WHO] Expert Committee, 1995). Since BMI was adopted by the WHO, it been used to classify individuals into weight categories of underweight, average weight, overweight, and obese.

Individuals who are classified as overweight or obese are considered to be at risk for a number of negative physical and mental health consequences, including poor body

image. Many researchers suggest that higher BMI is associated with poorer body image (Austin et al., 2009; Gualdi-Russo et al., 2008; Loth et al., 2015; Shriver et al., 2013), while others suggest that BMI may not be an important factor for body image development (Olvera et al., 2005; Seock & Merritt, 2013; Welch et al., 2004). It is critical to clarify the relationship between weight status and body image to see if specialized prevention programs are needed for youth living at a higher average weight.

Research examining the association between BMI and body image in children tends to support the idea that having a higher BMI is associated with having a poorer body image (Gualdi-Russo, 2008; Loth et al., 2015). For example, a study of 866 Italian children (8-9 years-old), examined the relationship between body image perception, and BMI measurements (Gualdi-Russo, 2008). Approximately 36% of participants had overweight or obesity, and 40% of children wanted to be thinner. The percentage of youth who wanted to be thinner increased to 73.6% of girls and 58.3% of boys who were living at a higher average weight. These results suggest that higher BMI is associated with greater body dissatisfaction in children.

Another study of 4,254 grade five students found similar results upon examination of body satisfaction, weight-related behaviours, sex, and BMI (Austin et al., 2009). There was a significant negative association between BMI and body satisfaction in girls. Specifically, higher BMI was associated with lower body satisfaction. For boys, there was a curvilinear relationship between body satisfaction and BMI, suggesting that boys with below and above average BMI had poorer body satisfaction than average weight boys.

Weight status or BMI has also been related to body image in studies of older children (Lee et al., 2004; Loth et al., 2015; Xanthopoulos et al., 2011). Loth and colleagues (2015), completed a 10-year longitudinal study of 496 adolescents with overweight or obesity. Researchers examined the relationship between baseline body satisfaction and BMI over time in boys and girls. No significant associations were found between boys' body satisfaction at baseline and their BMI 10 years later. However, researchers found that girls with the lowest body satisfaction at baseline had on average, a three-unit increase in BMI at the 10-year follow-up compared to girls with higher body satisfaction at baseline. Therefore, having a higher body image may be beneficial for long-term weight management in girls living at a higher average weight. While this finding varies from other research suggesting that high BMI leads to poorer body image, this research supports the contention that this relationship might be bidirectional.

In contrast to this body of research, other studies have not found consistent associations between body image and BMI (Abbott & Barber, 2010; Tremblay & Lariviere, 2009; Raustorp et al., 2009). In a study of 320 high school girls, Seock and colleagues (2013) examined the relative impact of BMI, peer teasing, and media influence on body satisfaction. Researchers found that BMI was the least important factor in predicting body satisfaction among girls. Likewise, Welch and colleagues (2004) did not find any sex differences in body image scores, or a significant association between weight status and body image perception among 524 children.

Similarly, research by Raustorp and colleagues (2009), did not find a significant association between children's self-perception of their body attractiveness and their BMI. Comparable findings were present in adolescent samples. Abbott and Barber (2010) did

not find a significant association between BMI and aesthetic satisfaction (similar to appearance satisfaction; *I feel very happy about the way I look*) among boys or girls. Another study found that there was not a significant correlation between body satisfaction and BMI in youth (Tremblay & Lariviere, 2009). Finally, there is research of adult populations to suggest that the high significant correlation between BMI and body image is contentious. Aljadini (2019), studied a sample of young adult women and found a very small correlation ($r = 0.14$) between body dissatisfaction and BMI (Aljadani, 2019). The prevalence of body dissatisfaction was high in this sample, while rates of obesity were low, thus the majority of women reported poor body image regardless of their size. This suggests that one need not have a high BMI, to report a negative body image.

Given this opposing research about the strength and existence of a consistent correlation between BMI and body image, it is important to further investigate the overall strength and presence of this association. It is possible that BMI may not be as important for body satisfaction as previous research suggests, particularly in adolescence and into adulthood. Although rates of overweight and obesity have increased (Johnson et al., 2008), body acceptance and satisfaction have also increased within the general population (Burke et al., 2012; Neighbors & Sobal, 2007; Rand & Resnick, 2000). This would suggest that having a higher BMI is not necessarily indicative of low body acceptance and satisfaction.

While many studies (as noted above) have indicated that BMI is a sufficient measure of obesity (Bell et al., 2018), there are major concerns about BMI as a measure of health including: (a) its inability to distinguish lean body mass and fat mass (i.e., someone can have a high BMI but a low fat mass; Flegal et al., 2009); (b) BMI does not

consider age, sex, addiction, or other physical and mental health comorbidities that have a large impact on overall health status and; (c) BMI may have a stronger correlation with lean body mass than fat mass (Romero-Corral et al., 2008), especially in men (Flegal et al., 2009), suggesting that BMI is not always representative of health.

Given these findings, it is possible that BMI is not necessarily a reliable index of being 'at risk' and that some individuals with a higher BMI can still be considered healthy and thus, conceivably have a positive body image. This measurement issue coupled with the body positivity and acceptance movements, might explain the varying research on the association between BMI and body image. The present thesis included a meta-analysis to quantify the association between BMI and body image in youth across weight categories, to further clarify this association and help to unpack the variability in the literature. This meta-analysis is important for informing weight management programming by indicating which mental and physical health characteristics are most associated with higher BMI to allow for more targeted interventions.

Obesity and Body Image

Researcher suggests, that on average, youth with obesity experience poorer body image than their average weight peers (Loth et al., 2015; Gualdi-Russo et al., 2008; Austin et al., 2009; Shriver et al., 2013). This association has been demonstrated across ethnicities (Cash & Smolak, 2011), age, and sex (Neumark-Sztainer, Croll, et al., 2002). A study of 4,746 youth (ages 11-18) from Project EAT found that 50% of boys with obesity had low body satisfaction compared to 20% of average weight boys, and 67% of girls with obesity had low body satisfaction compared to 33% of average weight girls (Neumark-Sztainer, Croll, et al., 2002). This is particularly troubling because low body

satisfaction in youth has been associated with a number of negative outcomes, such as low self-esteem, depression, disordered eating, and poor quality of life.

In a study of 1,491 youth with average weight, overweight (*N* = 265), and obesity (*N*= 146) from central Canada, researchers examined the association between weight status, dietary restraint, and body image (Goldfield et al., 2010). Youth with obesity reported lower body esteem than youth in the overweight and average weight categories. In addition, youth with obesity reported significantly more dietary restraint than youth in the overweight and average weight categories. This is problematic because dietary restraint has been associated with weight gain and adverse health consequences in youth (Farhat et al., 2014).

Another study of 8,028 youth in grades six to ten examined the impact of body image on the relationship between overweight and obese weight status and chronic disease-related health practices (e.g., lack of physical activity, infrequent breakfast consumption, screen time, and smoking). Researchers found that for boys, having a negative body image explained the association between overweight or obesity and screen time, and breakfast consumption (Farhat et al., 2014). For girls, body image mediated the relationship between obesity and physical activity, breakfast consumption, and smoking, and for overweight status and screen time (Farhat et al., 2014). That is, for girls, having a negative body image explained the association between obesity and physical activity, breakfast consumption, and smoking; and the association between overweight and screen time. Therefore, it is possible that body image interventions could reduce adverse health behaviours in youth with obesity.

In addition, van den Berg and Neumark-Sztainer (2007), found a significant negative association between body satisfaction and BMI after adjusting for sociodemographic variables and baseline BMI in girls with overweight and obesity. Upon examination of the mean change in BMI over five years, findings indicated that girls with higher body satisfaction had smaller increases in BMI five years later. Therefore, having higher body satisfaction may be protective against increased BMI in girls living at higher weights.

There has been controversy about whether having poor body image is a motivating factor for health behaviours for youth with obesity (Heinberg et al., 2001). Results of a five-year longitudinal study indicated that body image could be a protective factor for adverse health behaviours in youth. Researchers examined 2,516 adolescents at two time points: T1 (mean age 12.8), T2 (mean age 17.2). Among girls, lower body satisfaction at baseline predicted higher levels of dieting, unhealthy and extreme weight control behaviours, binge eating, lower levels of physical activity and fruit and vegetable intake five years later (Neumark-Sztainer, Paxton, et al., 2006). The association between extreme weight control behaviours, physical activity, dieting, and body satisfaction was still significant after controlling for BMI (Neumark-Sztainer, Paxton, et al., 2006). This suggests that (regardless of BMI) having higher body satisfaction is advantageous for reducing future unhealthy weight control behaviours, and may lead to more positive outcomes such as increased physical activity, and fruit and vegetable intake in girls.

Among boys in the study, lower body satisfaction predicted more dieting, unhealthy weight control behaviours, binge eating, smoking, and lower levels of physical activity. After controlling for BMI, all of these relationships remained statistically

significant except for smoking and unhealthy weight control behaviours. This suggests that boys with higher body satisfaction are less likely to engage in negative health behaviours five years later (Neumark-Sztainer, Paxton, et al., 2006). These findings indicate that poor body image does not motivate youth to engage in health behaviours. Rather, poor body image is associated with variables that put youth at risk for weight gain and poorer health.

Similar findings were present in a 10-year longitudinal study where girls with overweight (above 85th percentile for BMI) with low body satisfaction at baseline increased their BMI by three units (10 years later), compared to a one unit increase among girls with high body satisfaction at baseline (Loth et al., 2015). While this association was not significant among boys with higher weight, results indicate that poor body image may be associated with weight gain in female youth with overweight and obesity. There are few studies that have examined the long-term impact of body image on BMI and health behaviours. These preliminary findings suggest that having a positive body image could lead to more positive health outcomes in youth with higher average weight, such as less disordered eating and better quality of life. Therefore, more research is needed to clarify the relationship.

Health-related outcomes associated with obesity. Youth with obesity are at risk for a number of adverse health behaviours, including disordered eating behaviours (Vander Wal & Thelen, 2000). The prevalence of disordered eating behaviours in youth with obesity is higher than for youth with average weight (Vander Wal & Thelen, 2000), and disordered eating behaviours have been linked to poor body image in youth (Neumark-Sztainer, Croll, et al., 2002; Neumark-Sztainer, Wall, Story, et al., 2003).

Although disordered eating behaviours are often associated with youth with eating disorders, similar eating behaviours are also prominent in youth with obesity.

Disordered eating is an umbrella term for a number of eating-related problems that can be found in people with weight-related disorders. For example, binge eating, extreme weight control behaviours, and restrained, emotional, and external eating are all forms of disordered eating behaviours. According to the DSM-5, binge eating involves recurrent episodes of binge eating at least once a week for three months without compensatory behaviours but also having feelings of guilt or upset (American Psychiatric Association, 2013). Extreme weight control behaviours include behaviours such as fasting, the use of laxatives or diuretics, excessive exercise, and taking weight-loss supplements (Neumark-Sztainer, Story, et al., 2002). Emotional and external eating both involve eating in response to cues that are not hunger (e.g., emotions or external things such as smells), and restrained eating involves ignoring hunger cues to try and reduce food intake (van Strien et al., 1986). These eating-related problems will be discussed in more depth in children with obesity.

In a longitudinal study of 2,526 adolescents (27.5% of girls and 25.2% of boys had overweight), weight-related problems (e.g., obesity, eating disorders, and disordered eating) were identified in 44% of females and 29% of males (Neumark-Sztainer et al., 2007). Approximately 40% of girls and 20% of boys with higher average weight engaged in at least one disordered eating behaviour (e.g., binge eating or extreme weight control behaviours). Significant predictors of overweight status at time two were body dissatisfaction (for girls), weight concern (for boys and girls), and weight importance (for girls; Neumark-Sztainer et al., 2007). These findings suggest that disordered eating is not

only associated with eating disorders such as anorexia and bulimia, but it is also found in youth with higher average weight. In addition, it appears that appearance and weight concerns are related to disordered eating.

There are three main types of disordered eating behaviours that have been associated with body dissatisfaction and obesity: restrained, emotional, and external eating (van Strien et al., 1986). Restrained eating includes trying to restrict one's eating frequency, and limit specific types of food (e.g., higher carbohydrate, fat, or caloric foods), often leading to over-eating as a result of restricting food intake when hungry. External eating involves reacting to your surroundings (e.g., eating because you smell something good rather than eating because you are hungry; or eating because someone else is eating). Emotional eating involves using food as a coping mechanism for dealing with emotional experiences such as anger, sadness, or anxiety (van Strien et al., 1986), often it is thought that this is due to trying to manage one's mood with food. These forms of disordered eating have been associated with higher BMI and obesity (van Strien et al., 2016; Webber et al., 2009). The wide array of disordered eating problems associated with obesity complicates the treatment process for clinicians and physicians who are trying to determine what (if any) form of disordered eating a child may have, how severe it is, and if the child has more than one disordered eating behavior.

Flament and colleagues (2012), examined the association between the internalization of thin and muscular body ideals, body esteem, and disordered eating behaviours in a study of 1,947 adolescents (810 males). Two subsets of body esteem were examined: weight esteem and appearance esteem. Weight esteem is a person's satisfaction with (and positive feelings toward) his or her own weight and body shape;

appearance esteem is a person's satisfaction with (and positive feelings toward) his or her appearance. Weight esteem partially mediated the association between the muscular ideal and restrained eating behaviours in males. This suggests that boys who scored high on internalization of body ideals were more likely to engage in restrained eating, and this relationship was attenuated by more positive feelings about one's weight. In addition, appearance esteem partially mediated the relationship between the muscular ideal and emotional and external eating behaviours in males, suggesting that having higher appearance esteem may be beneficial for reducing emotional and external eating behaviours in boys.

In females, weight and appearance esteem partially mediated the relationship between internalization of the thin ideal and all three forms of disordered eating behaviours (i.e., restrained, emotional, external; Flament et al., 2012). These findings are indicative of a prominent association between disordered eating behaviours and body esteem; suggesting that having a positive body image may play an important role in reducing disordered eating behaviours in youth. This is particularly important for youth with obesity, as they are more likely to develop disordered eating and have lower body esteem (Stice, Argas, et al., 1999; Wardle & Cooke, 2005). Poor body image has also been linked to unhealthy weight control behaviours (e.g., fasting, skipping meals, smoking, and vomiting) among youth with obesity.

In a national study of 4,746 adolescents, 57.5% of girls and 32.8% of boys reported using unhealthy weight control behaviours in the past year (Neumark-Sztainer, Wall, et al., 2003). Unhealthy weight control behaviours included eating very little food, skipping meals, fasting, using food substitutes, smoking cigarettes, self-induced

vomiting, taking diet pills, and using diuretics and laxatives (Neumark-Sztainer, Wall, et al., 2003). Girls reported using an average of two-to-three unhealthy weight control behaviours and boys reported using an average of two unhealthy weight control behaviours in the past year. In addition, 18.2% of girls and 7.9% of boys reported frequent dieting (more than five times) over the past year. Strong associations were found between unhealthy weight control behaviours and weight-body concerns (another term for body esteem), family-peer weight norms and teasing behavior, and psychological well-being in youth.

Structural equation modeling was used to explain unhealthy weight control behaviours in boys and girls. Among girls, weight-body concerns were associated with unhealthy weight control behaviours, and family-peer weight norms were associated with higher weight-body concerns while family connectedness was related to fewer weight-body concerns (Neumark-Sztainer, Wall, et al., 2003). These variables explained 76% of unhealthy weight control behaviours in girls. For boys, a similar model was found with the addition of family-peer teasing behavior being associated with weight-body concerns. These variables explained 63% of the variance in unhealthy weight control behaviours in boys (Neumark-Sztainer, Wall, et al., 2003). These findings suggest that having fewer weight-body concerns may be advantageous for improving unhealthy weight control behaviours. This further demonstrates that improving body image may be particularly important for reducing disordered eating behavior in youth.

Research has linked the prevalence of unhealthy weight control behaviours with overweight status in boys and girls (Boutelle et al., 2002). It was found that as overweight status increased, so did dieting behaviour (Boutelle et al., 2002). Boys with higher weight

were three to four times more likely to diet compared to average weight boys, and girls with higher weight were two times more likely to diet than average weight girls. In addition, youth who were categorized as moderately overweight or obese were more likely to report exercising to lose weight than their average weight peers (Boutelle et al., 2002). It is important to highlight that dieting is seen as an unhealthy weight control strategy as it is ultimately associated with weight gain and poor psychological and physical outcomes in youth (Neumark-Sztainer, Wall, et al., 2007; Neumark-Sztainer, Wall, et al., 2012; Stice & Bearman, 2001). Additionally, restricting one's food intake and engaging in dieting behaviours are considered harmful because they can lead to over-eating, weight gain, decreased metabolic rate, digestive problems (e.g., constipation), lower energy, decreased concentration, increased anxiety, and depression (Davison et al., 2003; Neumark-Sztainer, Levine et al., 2006; Stice, Cameron, et al., 1999; van den Berg et al., 2007). Therefore, accepting their weight and engaging in health behaviours may be beneficial for improving mental and physical health across the weight spectrum.

Research has found that body dissatisfaction is related to a number of unhealthy weight control behaviours including, dieting, fasting, skipping meals, vomiting, and using diet pills or laxatives (Neumark-Sztainer, Paxton, et al., 2006). This is problematic for youth with obesity because on average, body dissatisfaction and disordered eating behaviours are higher among youth with obesity than youth with average and overweight (Wardle & Cook, 2005; Goldfield et al., 2010).

The research comparing the body image of children with obesity and children with eating disorders (e.g., anorexia nervosa, bulimia nervosa, and binge eating) is unclear. However, it is known that poor body image is a diagnostic criteria for eating

disorders, including binge eating (American Psychiatric Association, 2013), and many youth with obesity report poor body satisfaction, at least subclinical disordered eating symptoms, or binge eating symptoms, making it difficult to determine if one group is at a greater risk for poor body image than the other (Fairburn et al., 1998; Stice, Agras, et al., 1999).

One study of female youth found that youth with higher average weight were less likely to receive anti-dieting advice (e.g., about the negative impact of diets and unhealthy weight control behaviours) compared to their average weight peers (Thompson et al., 2006). It is speculated that this could be due to the misconception that people with higher average weight should engage in dieting behaviours. Therefore, these youth are at an even greater risk for the development of disordered eating behaviours due to their lack of education about eating behaviours, and increased probability to have poor body image.

Tanofsky-Kraff and colleagues (2009), classified 162 children into average, overweight, or obese categories to determine if there were any differences in eating disorder behaviours, restrained eating, weight and shape concerns, and eating concerns. Researchers found that children living at higher weights scored significantly higher on the global eating disorder scale, restrained eating, weight, shape, and eating concerns (Tanofsky-Kraff et al., 2009). Children with obesity had significantly higher global eating disorder scores, and weight and shape concerns than youth with average or overweight, suggesting that youth with obesity may be at an even higher risk for disordered eating and poor body image than both their average and overweight peers.

Vander Wal and Thelen (2000), found similar results in a study of 526 children who completed measures of body image, dieting behaviour, and concerns about eating

and becoming overweight. Children with obesity were significantly more likely to engage in dieting behaviour, restrained eating, experience weight concerns, and have more body dissatisfaction than their peers. These findings are alarming because disordered eating and poor body image have been associated with lower quality of life in youth with obesity (Hoffmann & Warschburger, 2015; Kurth & Ellert, 2008).

Quality of life. Children with obesity may experience a lower quality of life than their average weight peers (Schwimmer et al., 2003). Quality of life can include a child's physical, social, emotional, school, and family functioning. Researchers have found consistent trends among weight status and quality of life (Hoffmann & Warschburger, 2015; Kurth & Ellert, 2008; Petracci & Cavrini, 2013). However, it is possible that this relationship may be mediated by body image (Kurth & Ellert, 2008; Hoffmann & Warschburger, 2015). In a study of 6,869 German youth (11-17 years old), researchers examined the impact of perceived obesity on quality of life (Kurth & Ellert, 2008). This data is from the German Health Interview and Examination survey where youth had their height and weight measured, and reported on items including health-related quality of life, and self-rated body image. Children were classified into weight categories: underweight (7%), average (70%), overweight or obese (17%). Overall, girls (54.5%) considered themselves "a bit too fat" or "far too fat" more often than boys (35.5%). In addition, 36.6% of girls and 44.1% of boys considered their weight and body to be "just right," and 49.4% of girls and 26.2% of boys with average weight perceived themselves as overweight, suggesting that youths' self-rated weight and body perception is distorted since we know that 70% of the youth had average weight. Kurth and Ellert (2008),

measured quality of life through the following domains: physical well-being, psychological well-being, self-esteem, family, friends, and school.

Researchers found that youth with obesity scored significantly lower on all quality of life domains except for family and psychological well-being (Kurth & Ellert, 2008). However, upon further exploration of the data, researchers found that perception of one's own weight was associated with the poorest quality of life in youth. More specifically, regardless of BMI, youth who perceived themselves as "far too fat" reported lower quality of life even compared to youth with obesity, especially on measures of self-esteem and psychological well-being. Youth who reported that their weight was "just right" showed better trends in quality of life compared to youth with average weight (Kurth & Ellert, 2008). Therefore, youth's perception of their own body as "just right" regardless of weight, might be a promising avenue for pediatric weight management to improve quality of life.

Another study of 4,338 youth, examined the association between BMI, physical activity, body image, body acceptance, and quality of life (Petracci & Cavrini, 2013). Researchers categorized children by weight status (20.5% overweight; 4.8% obese). Overall, 55.7% of youth reported exercising more than two hours a week, and 62.5% reported that they accepted their physical appearance. Youth with overweight and obesity, reported poorer quality of life than average weight youth; and low body acceptance and poor self-perceptions were significantly associated with lower quality of life in all youth. These findings suggest that living at a higher weight, and having poor body image are risk factors for a lower quality of life in children.

Gouveia and colleagues (2014) reported similar findings among 250 youth (ages 8-18). Youth with obesity reported poorer quality of life, more internalizing and externalizing problems, and more body dissatisfaction than average weight youth. In addition, body image mediated the association between weight status and quality of life in youth over 12-years-old, suggesting that body image may explain the association between weight status and quality of life in youth (Gouveia et al., 2014).

Finally, Hoffmann and Warschburger (2015), measured weight-related quality of life, body image, and BMI in 408 children (9-12 years old) participating in a weight management program for obesity. Children completed these measures at baseline and then at a 12-month follow-up. At baseline, 91.9% of children reported body discontent, and 75.7% self-identified a body-size silhouette that was smaller than their actual body size. This is consistent with height and weight research that indicates that children tend to underestimate their weight and overestimate their height in self-report data (Pérez et al., 2015). Youth who were more dissatisfied with their bodies, and those who had a more realistic perception of their body size, reported lower weight-related quality of life, suggesting that body perception (underestimating size) and having a positive body image may be protective factors for quality of life in youth with obesity. It appears that children living at higher average weight are at a greater risk for poor quality of life. In addition, this association may be amplified in youth with poorer body image. It is possible that having a negative perception of one's own weight and shape is more damaging to youth's quality of life than their actual weight status. More longitudinal research is needed to clarify the connection between body image, and quality of life in youth with obesity.

Summary

Taken together, the results from the current literature review on body image, obesity, and health outcomes indicate that better body esteem may be advantageous to improve negative health-related outcomes in children with obesity. Research suggests that children with obesity are more likely to report disordered eating behaviours and poor quality of life. However, it remains unclear whether this is solely due to their weight or if it is a result of their (more negative) body image. Children begin reporting body dissatisfaction at a young age, indicating that early intervention is crucial before body image begins to decline into adolescence. The research continues to be conflicting about whether girls experience more body dissatisfaction than boys, but it appears that at higher ends of the weight spectrum, the gap may be closing, and the current discrepancies may be due to the nature of the measures being used. Youth with obesity are at the highest risk for disordered eating behaviours and poorer quality of life. Encouraging a positive body image could be instrumental in improving the physical and mental health of youth with obesity.

Pediatric Weight Management Centres

The current gold standard treatment for childhood obesity includes a family-centred multidisciplinary approach involving lifestyle modification with a focus on health behaviours within the family (Hughes & Reilly, 2008). However, among clinicians and researchers there continues to be disagreement about the most effective approach to managing obesity. Despite best efforts, many clinicians and researchers have found that the impact of child obesity interventions have been modest (Avis et al., 2013).

One case study in England found encouraging results after evaluating five families that participated in a family-based weight loss and healthy lifestyle program for children with obesity (Jinks et al., 2013). Four of the five children had reduced BMI at the end of the program, and the majority of participants indicated improvements in their diet, level of physical activity, self-esteem, and depressive symptoms. Due to the small sample size and no long-term follow-up period, these findings could not be generalized to the population, but it does provide a glimpse of pediatric weight management.

Braet and colleagues (2004) examined the impact of a 10-month inpatient treatment program for children with obesity that consisted of a non-diet, healthy lifestyle approach. One hundred and twenty-two children with obesity (ages 7-17) participated in the program. The intervention focused on healthy eating habits, moderate exercise, and cognitive behavioural therapy. At the 14-month follow-up, 12 patients did not return (Braet et al., 2004). On average, children lost 20.9kg during the 10-month treatment, and at the 14-month follow-up youth had maintained 30% of their weight loss. However, focusing on weight loss as a measure of success for youth with obesity is problematic because it is difficult to achieve and sustain. Trying to maintain significant weight loss can lead to weight cycling which is biologically and psychologically harmful, as weight cycling has been associated with increased inflammation (which increases risk for obesity-associated diseases; Strohacker & McFarlin, 2010), chronic stress (Tomiyama et al., 2010) and anxiety about weight (Davison et al., 2003). The most encouraging finding from this study was that at the 14-month follow-up, youth reported that they had maintained healthy eating behaviours, and had improved psychological well-being despite increases in weight.

Researchers in the United Kingdom studied 126 children with obesity who participated in a childhood obesity program (Sabin et al., 2007). The goal of the program was to decrease BMI by 0.5 standard deviations (SDS) or more. The median age of children was 11.7 years of age. Over a three and a half year period, 36 patients dropped out of the program, 79 remained in the program, and 11 were discharged (due to meeting the target reduction in BMI SDS). Of the entire sample, 70% reported reductions in BMI SDS and 18% reported the goal decrease of 0.5 standard deviations. Results indicated that 58 children participated in the program for more than one year; of those children, 83% had a reduction in BMI, and 28% reported the target BMI reduction respectively. These findings suggest that long-term engagement in weight management programs may result in better outcomes for youth. However, no psychosocial outcomes were examined in this study, and the largest BMI reductions were in younger children, boys, and children without parental history of obesity, limiting the generalizability of results on long-term overall health and well-being.

Another study that examined 5-18 year-olds who were part of an interdisciplinary, family-centered pediatric weight management clinic in Edmonton found that the patients BMI slightly decreased over time (Avis et al., 2013). Expectedly, researchers found that the number of appointments attended was related to the child's reduction in body weight over a three-month period (Avis et al., 2013). Moreover, there was no follow-up reported in this study and no psychosocial variables were examined, making it difficult to determine any long-term impact of the program on overall health. It is important to mention that weight-loss goals for obesity are modest in nature and should not be the focus of weight management as children are unlikely to move to a different BMI category

(e.g., overweight or average weight). Therefore, it is critical that pediatric weight management programs focus on sustained health behaviours as an outcome of success (i.e., balanced eating behaviours, and improved quality of life) rather than weight.

Poor attrition rates, short-term (or no) follow-ups, and few psychosocial indicators in weight management programs are leading to difficulties interpreting any long-term impact. One study examined reasons for discontinuing care for weight management (Dhaliwal et al., 2016). Parents of 10-17-year-old youth who were part of Canadian pediatric weight management programs were interviewed. Three main themes emerged for parental reasons for discontinuing care: 1. Family factors (e.g., perceived lack of progress, lack of family support, child's lack of motivation); 2. Logistical factors (e.g., cost, distance, scheduling); 3. Health services (e.g., unmet expectations, limited success, did not think they needed the program; Dhaliwal et al., 2016). It is possible if weight management programs worked toward addressing these issues that better outcomes would be observed and retention rates enhanced.

Standard treatment protocols for youth in Canada are different from other countries, in particular the U.S., as Canada does not frequently perform bariatric surgery for youth. In the United States, youth as young as 14, with a BMI greater than the 99th percentile, are eligible for some form of bariatric surgery (e.g., gastric bypass, laparoscopic gastric banding, sleeve gastrectomy; Zeller et al., 2011). Results for surgery among youth have been controversial and often include weight regain 1-year post surgery, and as weight increases post-surgery, health-related quality of life tends to decrease.

In Canada, bariatric surgery is not widely recommended for children due to the drastic lifestyle changes that are required post-surgery (e.g., strict eating behaviours and exercise requirements), and lack of long-term research on the medical and psychological impact of the surgery. Instead, there is a greater focus on multidisciplinary weight management centres to help improve the lives of children living with obesity. However, a recent study of adolescents ages 12-17 with severe obesity who underwent bariatric surgery combined with multidisciplinary obesity management had promising results (Akinkuotu et al., 2019). Specifically, those who received laparoscopic Roux-en-Y gastric bypass (RYGB; creation of a small gastric pouch) or sleeve gastrectomy (i.e., size of the stomach is decreased by 80%) had superior immediate weight loss and the most positive results (in terms of weight and BMI) up to two years post-operative, and lower rates of reoperation compared to those who received gastric banding. It is important to note that any type of bariatric surgery has restrictive post-operative lifestyle changes and a significant impact on gut hormones. Given this, bariatric surgery remains uncommon among children in Canada, and instead, the focus remains on multidisciplinary weight management.

Current programs in Canada are aiming to shift the focus from weight management to health promotion to increase health behaviours rather than focusing on weight. One review study found six randomized controlled trials that examined the impact of the Health at Every Size approach (HAES) on weight management; where people with obesity participated in programs that had shifted away from using BMI as the only indicator of program success, and instead focused on psychosocial measures such as quality of life, and health-related behaviours (Bacon & Aphramor, 2011). More

specifically, researchers found that individuals who participated in HAES programming reported improvements in physiological measures, health behaviours, and psychosocial outcomes (Bacon & Aphramor, 2011).

The HAES approach has three main areas of focus: 1. Encouraging body acceptance, 2. Intuitive eating (i.e., listening to your hunger cues), and 3. Active embodiment (i.e., building physical activity into one's day rather than focusing on structured exercise time; Bacon & Aphramor, 2011). Participants in Study 2 of the current thesis participated in a HAES-based program.

Canadian programs

Currently, there are 28 pediatric weight management centres in Canada (Obesity Canada-Find a clinic map locator, Map, 2018). Of these centres, some are program-based, while others are led by individuals who specialize in the treatment of pediatric obesity. There are at least 18 programs in Canada that are physician referred using a multidisciplinary approach (Ball et al., 2011). However, these programs have different structures: 15 target children and youth, 17 require parental participation, and only five of the programs are currently being evaluated. Further, the services provided in these programs vary: 16 include lifestyle/behavioural counselling, 8 have structured exercise programs, 6 involve energy-reduced diets, and 5 programs use pharmacotherapy. In addition, 16 of the programs include one-on-one care, and 13 use group-based intervention. Finally, there are some discrepancies in the required inclusion criteria for each program. Nine programs require that youth have a BMI greater than or equal to the 85th percentile, four programs require that youth have a BMI greater than or equal to the 95th percentile, and the remaining five programs have identified their criteria as "other."

Study 2 of the present thesis examined results from the first two years of a multidisciplinary hospital-based pediatric weight management program in eastern Canada.

Canadian guidelines are focused on family-centred approaches to pediatric obesity (Avis et al., 2014), and suggest that no single treatment will be entirely effective for all youth. Rather, it is important to tailor treatment to each child and their family. Researchers and clinicians have stressed the importance of communicating with families and indicating that the goal is to improve overall health and well-being while taking the focus off of actual weight. In addition, clinicians are indicating a need for more research about determining the best practices to talk to youth about body insecurities to help manage health (Avis et al., 2014).

Program of interest. Study 2 of the present thesis examined a clinical sample of youth with severe obesity from a weight management program in tertiary care that includes an interdisciplinary team comprised of a pediatric endocrinologist, two part-time psychologists, dietician, activity specialist, social worker, child and youth worker, and a nurse (Centre for Healthy Active Living [CHAL], n.d.). This program aims to improve the quality of life of children and youth living with obesity and their families by targeting body image, eating behaviours, sleep, mental health, physical activity, school supports (e.g., around weight-based bullying, learning concerns), family communication around health, and managing comorbidities; the team also works to understand and address social barriers to health for each family (e.g., will provide aid in acquiring financial assistance to families, mental health supports for parents). This team works with each child and their family to develop an individualized program that is best suited to help

with the child's weight management. Patients are assessed at baseline, 6, 12, 18, and 24 months, at which time they are discharged from the program. This program works with youth and parents by having a comprehensive full-day interdisciplinary assessment, group sessions, and individual follow-up appointments using the Health at Every Size Framework. This means that CHAL clinicians embrace the HAES approach by celebrating patients small successes related to intuitive eating, active embodiment, body acceptance, and bettering their mental health rather than focusing on weight change.

Managing obesity is difficult because it is a complex chronic disease with a number of comorbidities and underlying factors (Obesity Canada - what causes obesity? n.d.). Many programs solely focus on the biological components of obesity, targeting eating behaviours and physical activity. This is problematic as it suggests to families that weight management is simply about one's diet and physical activity (Avis et al., 2014). Weight science research suggests that weight management is much more complex and that other health indicators such as one's mental health and sleep behaviours are important to consider (Avis et al., 2014). Despite the evidence suggesting the importance of body image in relation to disordered eating, mental health, and quality of life in children and youth, the role of body image in youth with obesity in weight management programs has yet to be thoroughly examined.

Present Thesis

The focus of Study 1 was to examine the association between BMI and health outcomes (i.e., body image, disordered eating, quality of life) in community samples of youth by conducting a meta-analysis on research in this area. It was expected that higher BMI would be associated with poorer body image, increased disordered eating, and lower

quality of life. Results of this study provided a clearer understanding of the role that BMI or weight status might play in the overall health of youth. Specifically, the strength and presence of the associations between BMI and these health outcomes aided in the decision making process to determine which variables were the most relevant to examine in Study 2 (e.g., if disordered eating was not significantly associated with BMI then it may not be as important to examine in clinical samples of youth in weight management).

In Study 2, I examined the role of body esteem on health outcomes in youth living with obesity who are part of a weight management program, and the bidirectional associations between body esteem, BMI, disordered eating, and quality of life over time. Of particular interest was the impact of body esteem on program outcomes over the first two years of treatment, including disordered eating, quality of life, and BMI, while controlling for sex, age, number of mental and medical health comorbidities at baseline, and total appointments attended. It was expected that there would be positive changes in treatment outcomes over time (i.e., less disordered eating, higher body esteem, higher quality of life, no change in BMI). Based on previous literature, it was hypothesized that:

1. Those coming into the program with higher body esteem would have less disordered eating, and higher quality of life (regardless of BMI) at baseline
2. Higher initial body esteem would be associated with greater decreases in disordered eating and greater increases in quality of life over time
3. Positive changes in body esteem would be related to enhanced outcomes (i.e., improved quality of life and less disordered eating) over time (while considering changes in BMI).

This research is important for understanding the experiences of individuals living with

obesity, improving treatment programs, and clarifying the importance of body esteem in the management of obesity.

Study 1

Current study

The goal of Study 1 was to examine the association between BMI and body image, disordered eating, and quality of life in community samples of youth to inform future research and weight management programs about the importance of these factors relative to BMI. Demographic (e.g., age, sex, country) and methodological variables (e.g., outcome measurement type, study quality, weight status measure) were coded as potential moderators of these effect sizes. Studies included community samples of youth who were not enrolled in weight management programs and did not have any other physical or mental health related problems (that were identified as a focus of the study). I chose to examine community youth to provide a full scope of the association of BMI and health outcomes across the weight spectrum. It is important to note that since this is a study of community youth, there was representation from youth in weight management and clinical populations but they were not be the focus of the studies that were included. This allowed for a broader look at these associations in the population among youth who may or may not be receiving treatment for a breadth of physical and mental health conditions, including obesity.

Demographic moderators

Sex differences are sometimes present in research on weight status, body image, and disordered eating. Research is conflicting about whether females report lower body image than males, and less is known about sex differences in disordered eating and

quality of life. Average age of the sample may also moderate the association between weight and health outcomes because puberty is a time of drastic body and hormonal changes, which might be related to stronger associations between BMI, body image and disordered eating – especially for youth with overweight or obesity. While country/location was coded for as an exploratory measure, the data were too sparse to examine this moderator.

Methodological moderators

A number of methodological moderators were coded for in this meta-analysis. However, due to scarcity of reporting, only construct and study quality were examined. These were considered exploratory moderators as no specific hypotheses were made about how they would impact the effect size of BMI and each outcome. However, one could speculate that studies that score higher on study quality may have smaller effect sizes due to the conservative nature of the studies. Study quality was measured using the National Heart, Lung, and Blood Institute Quality Assessment Tool for observational cohort and cross-sectional studies (Appendix B). This measure of study quality focused on how, and if, the research questions were stated, there was clear operationalization of variables, generalizability of results, and appropriate justification for statistical analyses.

Methods

Study selection

This search used variations of the following search terms: BMI, weight status, obesity, body image, disordered eating, eating disorders, quality of life, children and youth, from January1973 to October 2017; while excluding bariatric surgery (see Appendix A). In the first stage of the review, articles were included or excluded based on

their title and/or abstract. In the second stage of the review, full-text articles were excluded if they did not meet the inclusion criteria from phase one and if they did not have a correlation table or report correlations in the text.

Studies were selected from five databases: PubMed, PsycInfo, Child Development and Adolescent Studies, Web of Science, and Dissertations and Theses Global from January 1973 to October 2017. I worked with a librarian to help optimize the search terms for each database. Search terms varied based on the keywords used in each database. The search terms were based on the sample (i.e., weight status, BMI, obesity; child*, adoles*, youth), outcome variables (i.e., body image, body satisfaction, body esteem; disordered eating, eating behav*, eating disorder; quality of life), exclusion criteria (i.e., NOT bariatric surgery), and language of publication (i.e., English). A variation of these terms was used for each database (see Appendix A for an example of one of the search strategies used). Additional studies were selected from review articles, and reference sections of the articles that were found.

Inclusion/exclusion criteria. There were seven inclusion criteria that had to be met: 1) participants varied over at least two different weight categories (underweight, average weight, overweight, obese); 2) some participants had overweight or obesity; 3) the study included one of the appropriate outcome measures of either body image, disordered eating, or quality of life; 4) included a child (6-12) or adolescent sample (13-25); 5) did not include a treatment or clinical sample; 6) did not include participants who had bariatric surgery, diagnosed eating disorders, or were from a special population (e.g., attending a diabetes clinic) and; 7) included the necessary statistics (i.e., correlation table, in-text correlations; see Appendix B for the screening manual).

Review strategy and data extraction. Studies were screened for inclusion criteria through two phases: 1) abstract and title, and 2) full text. For phase one, three coders each screened two-thirds of the abstracts and titles. At this phase, two individuals screened each abstract and title; for a study to be excluded both screeners had to agree that the study did not meet the criteria. If there was uncertainty or disagreement between coders, the study was retained until the second phase. For phase two, full texts of all remaining articles were retrieved, and data was screened by the same three coders based on the original seven criteria. Again, if there was any uncertainty between coders, the study was retained and examined for data extraction by the primary investigator.

Coding the studies. A coding instrument was developed to address all study, participant, and outcome characteristics (see Appendix C). Items included: participant characteristics (age group (child, adolescent), sex, BMI classification, average BMI, average age of participants); study characteristics (sample size, study methodology, study quality, year of publication, and type of publication); outcome characteristics (correlations between BMI and outcomes - disordered eating, body image, quality of life). For a small sample of studies that did not include correlation coefficients, authors were contacted. After receiving no responses, we did not continue this process, to improve efficiency. If a study included more than one correlation (e.g., males vs females; silhouette findings vs Likert scales), they were entered separately.

Two coders (principal and secondary) completed data extraction for 25% of the studies to determine inter-coder reliability. A random selection of studies was chosen for the secondary coder for each outcome. Reliability between the two coders was 99.3% for quality of life, 89.9% for disordered eating, and 91.0% for body image. The discrepancies

between coders were examined to see if there were any major differences in coding or if they were due to construct interpretation. Finally, with the secondary coder, these differences were discussed, and the two coders came to an agreement on interpretation.

Analyses

Random vs fixed effects. Meta-analysis allows for the use of fixed or random-effects models. A fixed-effects model assumes that there is one effect, all studies share a common effect size, and any difference is due to sampling error. Additionally, fixed-effects have increased power to detect an effect but also have an increased chance of Type I error. Due to the restrictive nature of a fixed-effects model, generalizability is limited to the set of studies included in the meta-analysis. A random-effects model has less power to detect an effect but is less likely to produce Type I errors. A random-effects model assumes heterogeneity of the effect sizes, which is more applicable to the current project as each study varies in methodology, and there is a wide distribution of measures, effect sizes, and sample sizes. In a random-effects model the effect size can be generalized to the population of effect sizes of which the current set of studies is a subset of. Therefore, the present meta-analysis used a random-effects model for the analyses.

Data analysis procedures. Three data-analytic software packages were used to complete this meta-analysis: Microsoft Excel (Microsoft Office, 2018), Comprehensive Meta-Analysis (CMA; version 3.3 070 Biostat, Inc., November 20, 2014), and IBM SPSS version 25 (IBM Corp., 1989, 2017). Microsoft Excel was used for data extraction and organization. IBM SPSS was used to determine any descriptive statistics. CMA was used to compute the overall mean effect size, examine subgroups, and test any moderators. The Pearson correlation coefficient was used as the effect size index for this meta-

analysis since all outcome variables were continuous. Fisher's *z* transformations were used to pool effect sizes, and then the *z* statistics were weighted based on sample size to account for power differences (Fisher, 1958; Hedges & Olkin, 1985). After appropriately weighting the *z* statistics, effect sizes were converted back to correlation coefficients (*r*) for interpretability. Effects size interpretations were based on past research and Cohen's recommendations that suggest 0.10, 0.30, 0.50 are small, medium, and large, respectively (Cohen, 1992).

Publication bias. It is common practice to examine publication bias in meta-analyses as it allows the researcher to determine if they have obtained a representative sample of the research studies available. This is determined by the visualization of the studies in a funnel plot. If there is no bias present in the studies selected, the studies will be distributed symmetrically around the combined effect size. If there is publication bias, there will be an unequal balance of studies on either side of the mean.

Funnel plots. The funnel plots demonstrate the study size (standard error) on the y-axis as a function of the effect size on the x-axis. Larger studies will appear near the top of the funnel plot while smaller studies will appear near the bottom. If the plot does not appear to be symmetrical, trim-and-fill procedures can be used to show how the effect size would shift if there was no bias.

Trim-and-fill. Duval and Tweedie (2000) developed the trim-and-fill method to help explain the impact of publication bias. The trim-and-fill method fills in the funnel plot with imputed values using an iterative procedure. These imputed values represent missing studies that if included, would remove the publication bias. Finally, trim-and-fill procedures will re-compute the combined effect size using the imputed studies.

A primary aim of Study 1 was to determine the overall association between BMI and body image. Therefore, a variety of body image tools and constructs were included in this meta-analysis. Upon coding the studies, it was discovered that these body image terms and measures (e.g., body esteem, weight satisfaction, appearance satisfaction etc.) may be heterogenous. Therefore, I present an overall association of BMI and body image that pools effect sizes across constructs, but the focus of this meta-analysis will be on the subcategories of body image that were identified.

Meta-Analysis Results

The overall systematic search resulted in 4,709 articles. An additional 44 articles were found by searching other systematic reviews and reference sections of articles. After duplicates were removed, 4,475 abstract and titles were screened for eligibility (see Appendix B), and 1,018 underwent full-text screening (see Appendix B and C). The Prisma diagram includes a detailed description of the workflow (see Figure 1).

Sample summary

Of the 106 studies included in this meta-analysis, the mean age of participants ranged from 6.03 to 21.43 and sample sizes varied from 29 to 5,218 participants. For body image, a total of 57 articles, with 77 independent subgroups from 1989-2017 were included in the meta-analysis. The total sample size included 30,988 participants and 54% of the studies were from North America. For disordered eating, a total of 46 articles, with 70 independent subgroups from 1993-2017 were included in the meta-analysis. The total sample size included 29,037 participants and 32% of the studies were from North America. For quality of life, a total of 21 articles, with 21 independent subgroups from 2003-2017 were included in the meta-analysis. The total sample size included 9,669

participants and 42% of the studies were from North America. It is important to note that some articles overlapped among constructs (e.g., one article may have included correlations between BMI and body image, and BMI and disordered eating) and therefore, the number of articles for each subsection appears to total to more than the overall number of articles included in the total meta-analysis.

The results of this meta-analysis are presented in three parts based on the outcome of interest 1) body image, 2) disordered eating, and 3) quality of life. Within each outcome, the overall effect of the outcome and BMI are presented, and subgroup analyses are reported on the total sample. Next, for the outcomes of body image and disordered eating, the overall construct was divided into subgroups and each subgroup was examined to determine the overall construct effect and if there are any moderators of these subgroups.

Figure 1

Prisma diagram of workflow for meta-analysis

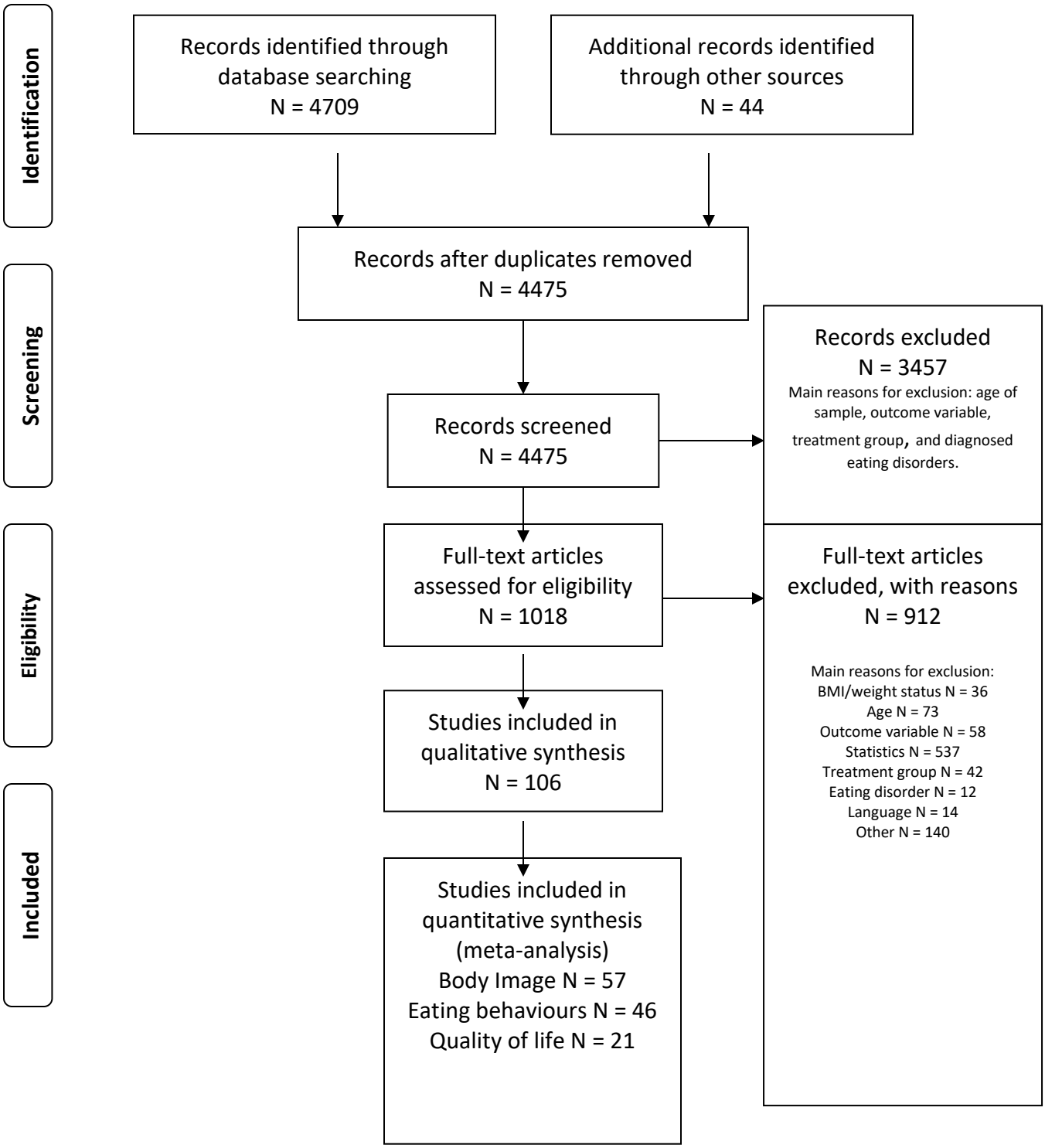


Table 1

Study characteristics and correlate categories extracted from body image studies

	Author, Year	*N*	M_{Age}	Sex	%Female	Continent	M_{BMI}	Construct	Study quality
1	Gaspar et al. (2011)	111	NR	female	100	Europe	NR	Appearance, distortion	2
	Gaspar et al. (2011)	119	NR	male	0	Europe	NR	Appearance, distortion	2
2	Ricca et al., (2010)	406	10	female	100	Europe	17.8	Weight	2
3	Raustorp et al., (2009)	41	12.7	male	0	Europe	18.8	Appearance	0
	Raustorp et al., (2009)	36	12.7	female	100	Europe	19.9	Appearance	0
4	Tremblay et al., (2009)	662	NR	both	52.7	North America	NR	Distortion	0
5	Erickson et al., (2009)	223	10.26	female	100	North America	23.11	Distortion, body image	5
	Erickson et al., (2009)	120	10.26	female	100	North America	21.92	Distortion, body image	5

	Author, Year	*N*	M_{Age}	Sex	%Female	Continent	M_{BMI}	Construct	Study quality
6	Kantanista et al., (2015)	1702	15.05	female	100	Europe	20.58	Body image	2
	Kantanista et al., (2015)	1547	15.1	male	0	Europe	20.63	Body image	2
7	Block (2010)	129	12.29	both	54	North America	22.43	Body image	4
8	Siervo et al., (2006)	50	18.6	female	100	Africa	20.6	Appearance	3
	Siervo et al., (2006)	50	19.3	male	0	Africa	19	Appearance	3
9	Webb et al., (2014)	247	17.8	female	100	North America	25.4	Body image, distortion	2
10	Javaid et al., (2014)	97	20.5	female	100	Asia	22.3	Body image, distortion	4
11	Laus et al., (2011)	139	16.2	male	0	South America	22	Distortion	-3
	Laus et al., (2011)	136	16.2	female	100	South America	21.7	Distortion	-3
12	Abbott et al., (2010)	673	13.83	male	0	Australia	NR	Body image, appearance	2
	Abbott et al., (2010)	853	13.83	female	100	Australia	NR	Body image, appearance	2

	Author, Year	*N*	M_{Age}	Sex	%Female	Continent	M_{BMI}	Construct	Study quality
13	Markland, et al., (2007)	50	16.9	male	0	Europe	20.54	Distortion	-2
	Markland, et al., (2007)	48	16.88	female	100	Europe	21.36	Distortion	-2
14	Nanu et al., (2013)	476	17.37	both	52.5	NR	21	Appearance, weight	0
15	Armstrong et al., (2012)	94	11.16	both	52.1	North America	NR	Distortion	-1
16	Tomlinson (2005)	108	14.35	female	100	North America	NR	Appearance	2
17	Chaiton et al., (2009)	1127	NR	male	0	North America	21.3	Distortion	0
	Chaiton et al., (2009)	1167	NR	female	100	North America	21.4	Distortion	0
18	Young-Hyman et al., (2006)	164	11.9	both	51	North America	NR	Distortion	-1
19	Vander Wal et al., (2004)	55	NR	female	100	North America	NR	Body image	0
	Vander Wal et al., (2004)	69	NR	female	100	North America	NR	Body image	0

	Author, Year	*N*	M_{Age}	Sex	%Female	Continent	M_{BMI}	Construct	Study quality
20	Field et al., (1993)	431	NR	female	100	North America	21.1	Weight	2
21	Hanna et al., (2006)	196	NR	female	100	Australia	21.27	Appearance	2
22	Raustorp (2010)	88	13.49	male	0	Europe	19.67	Body image	2
	Raustorp (2010)	69	13.63	male	0	Europe	20.28	Body image	2
	Raustorp (2010)	103	13.37	female	100	Europe	20.53	Body image	2
	Raustorp (2010)	101	13.54	female	100	Europe	20.98	Body image	2
23	Ahern et al., (2006)	86	NR	female	100	Europe	NR	Appearance	4
24	Anschutz et al., (2011)	60	9.21	female	100	Europe	NR	Distortion	2
25	Hansson et al., (2010)	1383	10.3	both	54.2	Europe	17.6	Appearance, weight	4
26	Jollie-trottier et al., (2009)	291	NR	both	52.6	North America	21.68	Distortion, body image	4
27	Fowler (1989)	90	15	female	100	North America	NR	Appearance	-1
28	Neumark-sztainer et al., (1995)	341	15.3	female	100	Asia	21.2	Appearance, distortion	0
29	Matton et al., (2013)	399	15.72	both	60.2	Europe	NR	Appearance, weight	3

	Author, Year	*N*	M_{Age}	Sex	%Female	Continent	M_{BMI}	Construct	Study quality
30	Porter (2008)	93	13.35	both	68	North America	38.5	Appearance, distortion	4
31	Johns (2015)	232	20.9	female	100	North America	26.69	Body image	2
32	Benson (2015)	38	9.05	both	63.2	North America	20.41	Distortion	2
33	Simons (2014)	40	6.03	female	100	North America	17.17	Distortion	2
34	Elledge (2014)	135	12.68	both	50	North America	NR	Appearance, distortion	3
35	Ward (2011)	110	9.12	female	100	North America	NR	Distortion	-2
36	Bayyari (2010)	410	20.01	female	100	Asia	21.91	Distortion	4
37	Elrod (2007)	3369	14.5	both	53	North America	NR	Distortion	1
38	Rorie (2004)	5218	15.78	female	100	North America	22.5	Distortion	0
39	Sira (2003)	510	19	both	63.6	North America	23.16	Appearance	6
40	Jones et al., (2005)	128	15	male	0	North America	22.49	Appearance	4
41	Klaczynski et al., (2009)	158	13.55	both	63.12	North America	NR	Body image	2
42	Pierce et al., (1997)	65	10.34	both	61.2	Europe	21.71	Appearance	3
43	Marsh et al., (2007)	763	10.5	both	45.5	Asia	18.42	Appearance, distortion	5

	Author, Year	*N*	M_{Age}	Sex	%Female	Continent	M_{BMI}	Construct	Study quality
44	Yates et al., (2004)	287	NR	male	0	North America	24.9	Distortion	0
	Yates et al., (2004)	472	NR	female	100	North America	22.15	Distortion	0
45	Labbrozzi et al., (2013)	134	12.55	female	100	Europe	21.4	Appearance	4
46	Darlow et al., (2010)	274	18.4	female	100	North America	23.2	Appearance	4
47	Megalakaki et al., (2013)	36	13.8	both	59.2	Europe	NR	Appearance, weight	4
48	Streeter et al., (2012)	75	21.4	male	0	North America	NR	Appearance, weight	4
	Streeter et al., (2012)	87	20.77	female	100	North America	NR	Appearance, weight	4
49	Cagas et al., (2015)	362	17.7	female	100	Asia	20.51	Appearance	0
50	Behdarvandi et al., (2017)	100	16.5	male	0	Asia	NR	Appearance, weight, body image	4
	Behdarvandi et al., (2017)	100	16.5	female	100	Asia	NR	Appearance, weight, body image	4

	Author, Year	N	M_{Age}	Sex	%Female	Continent	M_{BMI}	Construct	Study quality
51	McHale et al., (2001)	81	15	female	100	North America	19.1	Weight	6
	McHale et al., (2001)	100	15	male	0	North America	19.2	Weight	6
	McHale et al., (2001)	87	12.5	female	100	North America	19.1	Weight	6
	McHale et al., (2001)	91	12.5	male	0	North America	19.2	Weight	6
52	Hausenblas et al., (2001)	192	12.43	female	100	North America	21.3	Distortion	2
	Hausenblas et al., (2001)	196	12.79	male	0	North America	21.1	Distortion	2
53	Mirza et al., (2005)	113	NR	both	NR	North America	NR	Distortion	2
54	Goldfield et al., (2010)	1471	14.59	both	57	North America	21.67	Appearance, weight	4
55	Carraro et al., (2010)	103	13.2	both	51	Europe	20.68	Appearance	6

	Author, Year	*N*	M_{Age}	Sex	%Female	Continent	M_{BMI}	Construct	Study quality
56	Rodgers et al., (2014)	488	12.35	female	100	Australia	20.47	Appearance, weight	4
57	Gowey et al., (2017)	220	10.32	both	53.64	North America	NR	Distortion	4

Note. NR = not reported; Appearance = appearance satisfaction; Weight = weight satisfaction; Distortion = body distortion/perception.

Table 2

Study characteristics and correlate categories extracted from disordered eating studies

	Author, Year	*N*	M_{Age}	%Female	Sex	Continent	M_{BMI}	Construct	Study quality
1	Mayer-Brown et al., (2016)	179	12.99	54.2	both	North America	NR	UWCB	5
2	Ricca et al., (2010)	406	10	100	female	Europe	17.8	ED general	2
	Ricca et al., (2010)	363	10	0	male	Europe	17.6	ED general	2
3	Tremblay et al., (2009)	662	NR	52.7	both	North America	NR	UWCB	3
4	Erickson et al., (2009)	223	10.26	100	female	North America	23.11	ED general	5

	Author, Year	*N*	M_{Age}	%Female	Sex	Continent	M_{BMI}	Construct	Study quality
	Erickson et al., (2009)	120	10.26	100	female	North America	21.92	ED general	5
5	Laghi et al., (2015)	140	17.48	100	female	Europe	21.33	Binge/LOC, external, emotional	5
	Laghi et al., (2015)	196	17.48	0	male	Europe	22.55	Binge/LOC, external, emotional, physical, social	5
6	Canan et al., (2014)	1938	16.05	52	both	Europe	20.58	ED general	6
7	Snoek et al., (2008)	404	15.2	NR	NR	Europe	19.87	Restraint	3
	Snoek et al., (2008)	404	13.5	NR	NR	Europe	18.94	Restraint	3
8	Maras et al., (2016)	3043	14.2	58.8	both	North America	21.28	Restraint, external, emotional	4
9	Gowey et al., (2014)	272	10.36	54.2	both	North America	NR	ED general, UWCB	3

	Author, Year	*N*	M_{Age}	%Female	Sex	Continent	M_{BMI}	Construct	Study quality
10	Armstrong et al., (2012)	94	11.16	52.1	both	North America	NR	UWCB	-1
11	Kayano et al., (2008)	106	18.73	0	male	NR	20.71	ED general	1
	Kayano et al., (2008)	51	15.15	0	male	NR	22.8	ED general	1
	Kayano et al., (2008)	72	15.24	0	male	NR	22.64	ED general	1
	Kayano et al., (2008)	41	15.1	0	male	NR	23.15	ED general	1
	Kayano et al., (2008)	87	15.29	0	male	NR	20.14	ED general	1
	Kayano et al., (2008)	305	18.68	100	female	NR	19.64	ED general	1
	Kayano et al., (2008)	79	15.9	100	female	NR	20.82	ED general	1
	Kayano et al., (2008)	63	15.52	100	female	NR	22.06	ED general	1
	Kayano et al., (2008)	72	15.04	100	female	NR	21.66	ED general	1
	Kayano et al., (2008)	109	14.61	100	female	NR	18.53	ED general	1
12	Braet et al., (2007)	498	10.1	63	both	Europe	26.4	Emotional	1
13	Vander wal et al., (2004a)	55	NR	100	female	North America	NR	ED general	1
	Vander wal et al., (2004b)	69	NR	100	female	North America	NR	ED general	1
14	Field et al., (1993)	431	NR	100	female	North America	21.1	UWCB	2

	Author, Year	*N*	M_{Age}	%Female	Sex	Continent	M_{BMI}	Construct	Study quality
15	Glasofer et al., (2013)	111	14.5	100	female	North America	27.1	Binge/LOC	-1
16	Ledoux et al., (2011a)	147	9.5	0	male	NR	NR	Restraint, emotional, external	3
	Ledoux et al., (2011a)	157	9.5	100	female	NR	NR	Restraint, emotional, external	3
	Ledoux et al., (2011b)	116	17.5	0	male	NR	NR	Restraint, emotional, external	3
	Ledoux et al., (2011b)	148	17.5	100	female	NR	NR	Restraint, emotional, external	3
17	Hanna et al., (2006)	196	NR	100	female	Australia	21.27	UWCB	2
18	Ahern et al., (2006)	86	NR	100	female	Europe	NR	Restraint	1
19	Jollie-trottier et al., (2009)	291	NR	52.6	both	North America	21.68	UWCB, emotional	1

	Author, Year	*N*	M_{Age}	%Female	Sex	Continent	M_{BMI}	Construct	Study quality
20	Soo et al., (2008)	489	16.2	100	female	Asia	21.9	Restraint, binge	5
21	Demir et al., (2017)	1201	NR	NR	NR	Europe	NR	Emotional	6
22	Matton et al., (2013)	399	15.72	60.2	both	Europe	NR	Emotional, external, restraint	3
23	Mitchell (2015)	165	9.41	50	both	North America	NR	ED general	6
24	Bayyari (2010)	410	20.01	100	female	Asia	21.91	UWCB	4
25	Rorie (2004)	5218	15.78	100	female	North America	22.5	UWCB	0
26	Sira (2003)	510	19	63.6	both	North America	23.16	ED general	6
27	Jiang et al., (2016)	147	21.43	100	female	NR	22.83	External, emotional, restraint	4
28	Goldfield et al., (2010)	1471	14.59	57	both	North America	21.67	Restraint, emotional, external	6
29	Pearson et al., (2013)	246	13	45.1	both	North America	21.45	Restraint, ED general	2
30	Lopez et al., (2013)	96	15.36	58	both	North America	22.5	Restraint	4

	Author, Year	*N*	M_{Age}	%Female	Sex	Continent	M_{BMI}	Construct	Study quality
31	Rodgers et al., (2014)	488	12.35	100	female	Australia	20.47	Restraint, UWCB	4
32	Gowey et al., (2017)	220	10.32	53.64	both	North America	NR	ED general, UWCB, restraint	4
33	Caradas et al., (2001)	228	16.2	100	female	Africa	22.5	ED general	5
34	White et al., (2003)	32	13.82	100	female	North America	21.54	UWCB	4
	White et al., (2003)	29	13.82	100	female	North America	21.55	UWCB	4
35	Lombardo et al., (2004)	735	16.25	100	female	Europe	20.2	ED general	4
	Lombardo et al., (2004)	843	16.25	0	male	Europe	21.6	ED general	4
36	Yannakoulia et al., (2004)	119	17.63	54	both	NR	22.3	UWCB	5
37	Schulte (2016)	236	19.78	64.8	both	NR	22.08	Binge/LOC, emotional	4
38	Forrester-knauss et al., (2012)	214	11.95	0	male	Europe	17.94	Restraint, emotional	5

	Author, Year	*N*	M_{Age}	%Female	Sex	Continent	M_{BMI}	Construct	Study quality
	Forrester-knauss et al., (2012)	214	11.97	100	female	Europe	17.87	Restraint, emotional	5
39	Masuda et al., (2011)	209	20.35	79	both	North America	23.19	ED general	3
40	Kirsch et al., (2016)	176	18.48	0	male	North America	23.67	ED general	3
	Kirsch et al., (2016)	475	18.48	100	female	North America	22.82	ED general	3
41	Hadjigeorgiou et al., (2012)	582	14	0	male	Asia	NR	ED general	3
	Hadjigeorgiou et al., (2012)	671	14	100	female	Asia	NR	ED general	3
42	Duarte et al., (2016)	497	16.03	100	female	Europe	21.12	ED general	3
43	Elfhag et al., (2005)	202	16.9	0	male	Europe	21.3	Restraint, emotional	3
	Elfhag et al., (2005)	279	16.8	100	female	Europe	21.6	Restraint, emotional	3
44	Halliwell et al., (2006)	250	13.23	100	female	Europe	14.41	ED general	5
	Halliwell et al., (2006)	257	13.32	0	male	Europe	15.71	ED general	5

	Author, Year	*N*	M_{Age}	%Female	Sex	Continent	M_{BMI}	Construct	Study quality
45	Mustapic et al., (2015)	187	16	100	female	Europe	NR	ED general	3
46	Rukavina et al., (2006)	123	16.24	100	female	NR	NR	ED general	3

Note. NR = not reported; ED general = Eating disorder general; UWCB = unhealthy weight control behaviours; Emotional = emotional eating; Restraint = restrained eating; External = external eating; Binge/LOC = binge eating and loss of control.

Table 3

Study characteristics and correlate categories extracted from Quality of life studies

	Study (Year)	*N*	M_{Age}	%Female	Continent	M_{BMI}	Construct	Study quality
1	Tzischinsky (2016)	844	14.60	54.1	Asia	20.14	TOT HRQOL	2
2	Wynne et al., (2016)	255	9.73	50.0	Europe	NR	TOT HRQOL	7
3	Jalali-Farahani et al., (2013)	465	15.56	48.8	Asia	23.06	TOT HRQOL	2
4	Costarelli et al., (2013)	359	13.1	53.7	Europe	19.90	Physical	2

	Study (Year)	*N*	M_{Age}	%Female	Continent	M_{BMI}	Construct	Study quality
5	Morrison et al., (2014)	244	12.19	51.2	North America	NR	TOT HRQOL	2
6	Gowey et al., (2014)	272	10.36	54.2	North America	NR	Tot HRQOL	2
7	Mitchell (2015)	165	9.41	50.0	North America	NR	TOT HRQOL	4
8	Burke (2015)	137	13.09	56.9	North America	NR	TOT HRQOL	2
9	Fiveash (2003)	848	9.84	48.8	North America	19.92	TOT HRQOL	6
10	Khodaverdi et al., (2011)	240	10	50.0	Asia	18.14	Physical & social	2
11	Boyle et al., (2010)	1771	13.2	48.3	Europe	18.00	TOT HRQOL	2
12	Strong et al., (2017)	497	10.63	52.9	Asia	19.60	TOT HRQOL	4
13	Pinhas-Hamiel et al., (2006)	182	11.35	58.8	Asia	24.67	TOT HRQOL	5
14	Schwimmer et al., (2003)	106	12.1	53.7	North America	34.70	Physical & social	2
15	Morales et al., (2011)	443	14.7	53.0	North America	27.10	Self, social & environment	3
16	Dalton et al., (2011)	152	11.79	53.9	North America	NR	TOT HRQOL	3

	Study (Year)	*N*	M_{Age}	%Female	Continent	M_{BMI}	Construct	Study quality
17	Edwards et al., (2012)	454	NR	53.0	North America	NR	TOT HRQOL	3
18	Gouveia et al., (2014)	260	12.5	56.2	Europe	23.95	TOT HRQOL	3
19	Helseth et al., (2015)	1066	NR	54.0	Europe	NR	Physical	2
20	Kaartina et al., (2015)	379	14.25	49.2	Asia	NR	TOT HRQOL	2
21	Meyer et al., (2016)	530	13.2	44.5	Europe	NR	TOT HRQOL	2

Note. NR = Not reported; TOT HRQOL = Total health-related quality of life; Physical = Physical quality of life; Physical & social = average score of physical and social quality of life combined; self, social, & environment = average score of self, social, and environmental quality of life.

Overall Body Image

Table 4 provides a summary of the meta-analysis results of the association between body image and BMI. There was significant heterogeneity in the magnitude of the correlation between BMI and body image (see Table 4). The results for the random-effects meta-analysis of the association between BMI and body image are presented first, followed by an examination of sex and construct differences of the effect size.

Table 4

Summary of meta-analytic results of the association between BMI and body image

	Overall Body Image
Heterogeneity (Q; df=76)	1177.40*
Random-effects Mean (ES)	-0.41*
95% CI	-0.45: -0.37

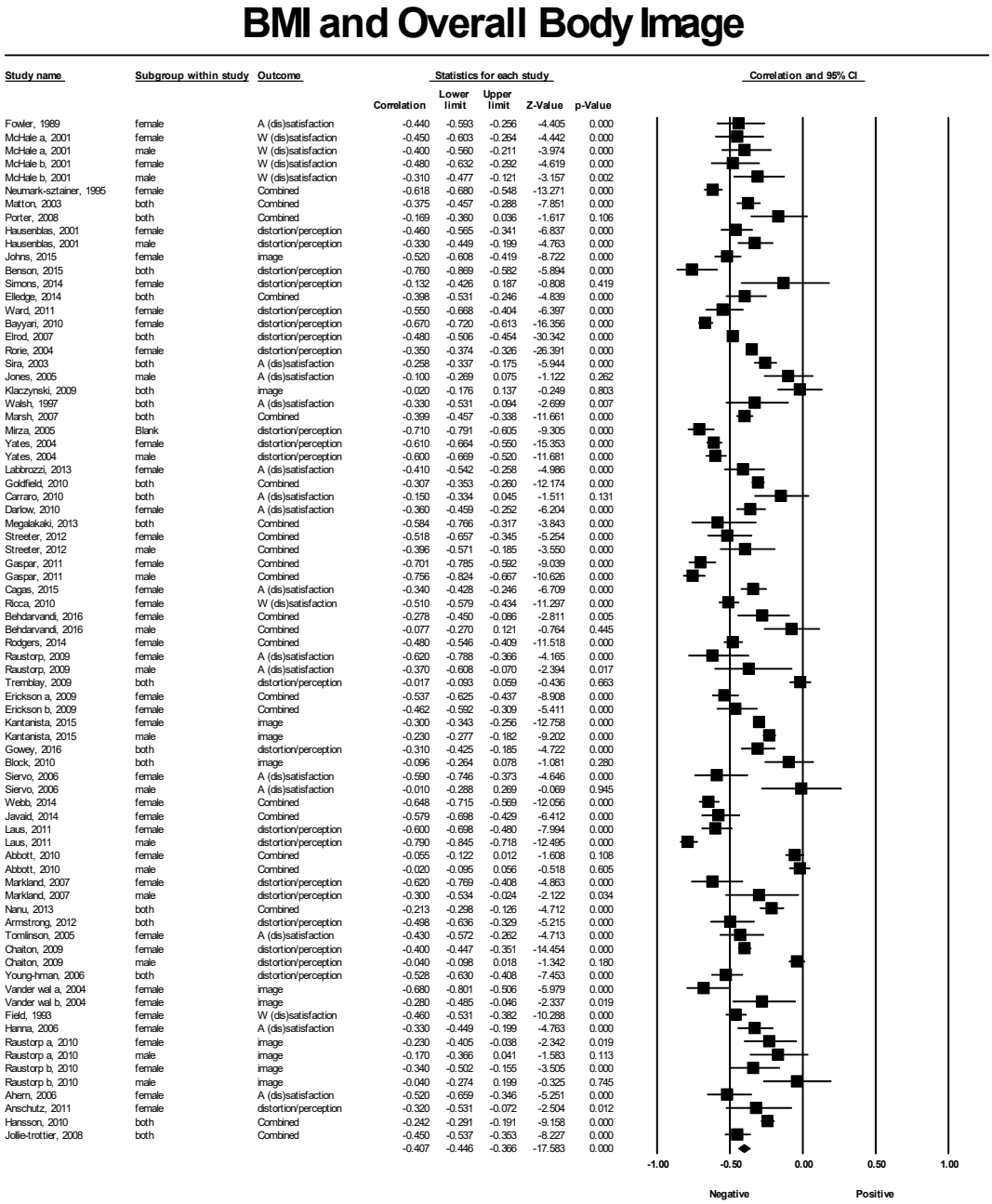
Note. ES = effect size.

*$p < .001$.

Magnitude of the relationship. Body image was expected to be negatively associated with BMI. Overall, the average correlation between body image and BMI was -0.41, which is a medium negative effect size, according to Cohen (1992). Figure 2 lists the studies included in this random-effects meta-analysis along with the distribution of their effect sizes around the summary effect size, r = -0.41. Heterogeneity in the effect sizes can be seen by the lack of overlap of the confidence intervals for the different studies. The presence of heterogeneity is tested using the Cochrane Q statistic to evaluate if there is heterogeneity between studies. This is important to examine as it is necessary to find potential moderators of the overall effect. Effect sizes ranged from -0.01 (a negligible effect), to -0.79 (a large effect).

Figure 2

Association between body image and BMI



Publication Bias. Visual inspect of the funnel plot for BMI and overall body image suggests that effect sizes are distributed relatively symmetrically around the

average effect size of -0.41 (Appendix E Figure E1). Further inspection of symmetry using Duval and Tweedie's (2000) trim-and-fill technique suggested that no additional studies needed to be added to this meta-analysis and the effect size did not need to be adjusted (see Appendix E Figure E1). This indicates that the sample of included studies is theoretically representative of the data even if studies were missed during the search process.

Moderators. Given the heterogeneity of the studies, it is important to examine potential moderators. Preliminary examination of the subgroups (e.g., sex of the sample), indicated that this may be an important moderator. For this meta-analysis, participant (i.e., sex, average age) and study characteristics (i.e., study quality, construct measured) were coded as possible moderators of the effect size.

Subgroup analyses. The trends in effect sizes suggest that there is stronger association between body image and BMI for females (see Table 5; Appendix F Figure F1). Subgroups analyses demonstrate a significant difference between groups. Results suggest that studies that examined female participants report effect sizes that are 1.5 times larger than studies that only examined males or studies that included males and females. This data was also coded for construct to determine if the type of body image that was measured would have a significantly different association with BMI.

Table 5

Sex differences in the association between overall body image and BMI

	Sex differences in body image
Sex ($Q_{b(1)}$)	16.87**
Both (k=21)	-0.33**
Female (k=39)	-0.47**

	Sex differences in body image
Male (*k*=17)	-0.32**

**$p < .001$

While coding the studies, it was evident that there was not a clear definition of body image that was used throughout the research (likely due to the broad nature of body image terminology). Rather, researchers appeared to classify body image constructs in a number of ways that the present study systematically categorized into: 1) appearance (dis)satisfaction – any study that examined participations feelings about their appearance; 2) body distortion/perception - any study that used a figure rating scale and overall body discrepancy score to represent body satisfaction or image; 3) weight (dis)satisfaction – any study that examined participants overall feelings about their weight or shape; 4) body image – studies that used general or total scores of body image, body esteem, or physical self-perceptions (see Appendix D for a glossary of terms).

Subgroup analyses suggest that there are differences in effect sizes based on the construct that was measured (see Table 6; Appendix F Figure F2). Studies that used body distortion/perception demonstrated the largest correlation with BMI, followed by weight satisfaction, appearance satisfaction, and body image. Due to the large differences in effect sizes between constructs and the heterogeneity within the subgroups and overall body image construct, studies were divided by construct and examined separately to try to tease apart the differences in effect sizes.

Table 6

Construct differences in the association between body image and BMI

	Construct associations with BMI
Construct ($Q_{b(1)}$)	30.03**
Appearance satisfaction (k=33)	-0.32**
Body distortion/perception (k=33)	-0.53**
Body image (k=20)	-0.30**
Weight satisfaction (k=16)	-0.40**

**$p < .001$. *$p < .05$.

Appearance Satisfaction

Table 7

Summary of meta-analytic results of the association between BMI and appearance satisfaction

	Appearance satisfaction
Heterogeneity (Q; df=32)	312.05*
Random-effects Mean (ES)	-0.32*
95% CI	-0.38: -0.26

Note. ES = effect size.

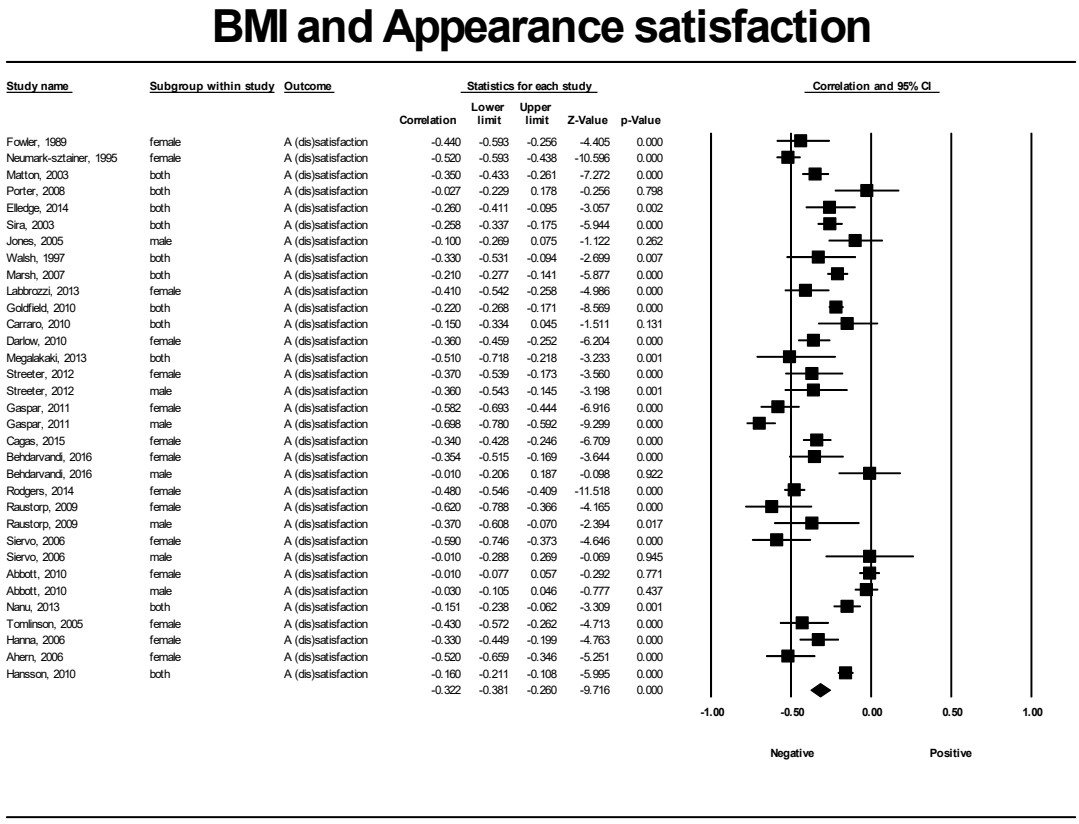
*$p < .001$

Magnitude of the relationship. There was significant heterogeneity in the magnitude of the correlation between BMI and appearance satisfaction (see Table 7). The average correlation between appearance satisfaction and BMI was -0.32, which is a negative medium effect size, according to Cohen (1992). Figure 3 lists the studies included in this random-effects meta-analysis along with the distribution of their effect sizes around the summary effect size, r = -0.32. Heterogeneity in the effect sizes can be

seen by the lack of overlap of the confidence intervals for the different studies. Effect sizes ranged from -0.01 (a negligible effect), to -0.70 (a large negative effect).

Figure 3

Association between BMI and appearance satisfaction



Publication bias. Visual inspection of the funnel plot indicates that there might be some studies missing from the right side of the plot (see Appendix E Figures E2). To confirm that there is asymmetry of this plot, Duval and Tweedie's trim-and-fill technique was used. Based on the results, five imputed effect sizes were added to the right side of the funnel plot (see Appendix E Figure E3). The addition of these imputed studies

resulted in a reduced effect size between appearance satisfaction and BMI of -0.27 (see table 8).

Table 8

Results of Duval and Tweedie's trim-and-fill for the random-effects model of the association between appearance satisfaction and BMI

	Studies Trimmed	Point Estimate	LL	UL	*Q*-value
Observed values		-0.32	-0.38	-0.26	312.05
Adjusted values	5	-0.27	-0.33	-0.21	378.67

Note. LL = lower limit; UL = upper limit

Body Distortion/Perception

Table 9

Summary of meta-analytic results of the association between BMI and body distortion/perception

	Body distortion/perception
Heterogeneity (*Q*; *df*=32)	885.87*
Random-effects Mean (ES)	-0.53*
95% CI	-0.59: -0.47

Note. ES = effect size.

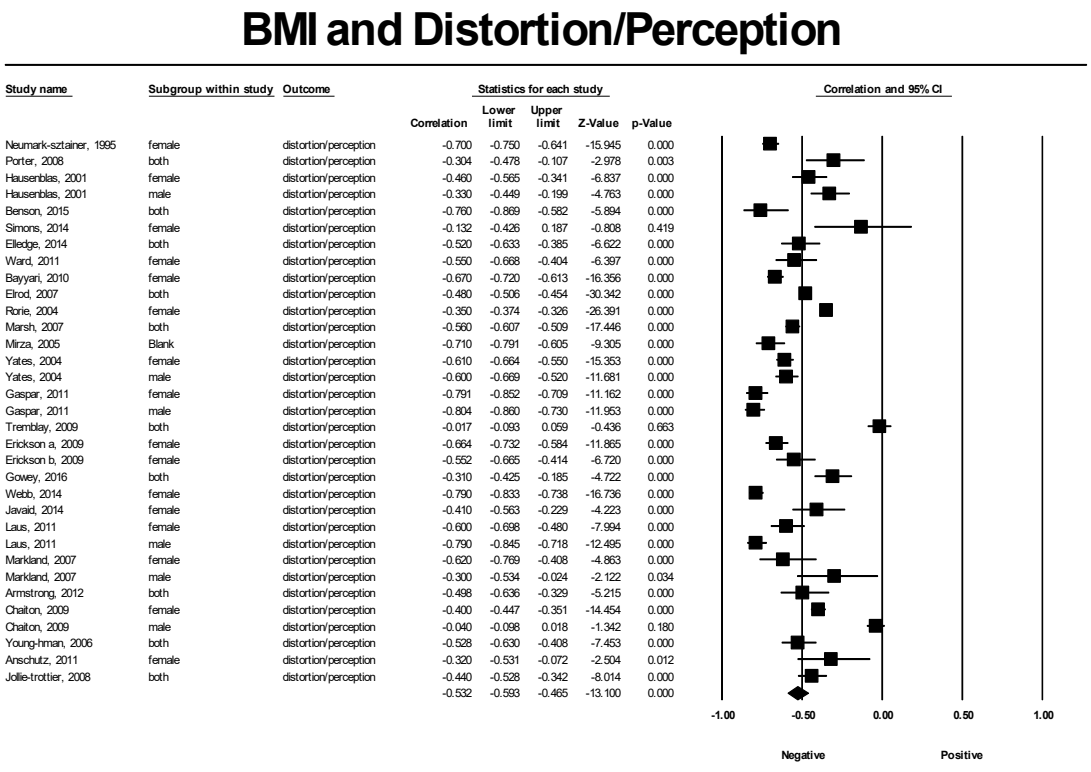
*$p < .001$

Magnitude of the relationship. There was significant heterogeneity in the magnitude of the correlation between BMI and body distortion/perception (see Table 9). The average correlation between body distortion/perception and BMI was -0.53, which is a large negative effect size, according to Cohen (1992). Figure 4 lists the studies included in this random-effects meta-analysis along with the distribution of their effect sizes around the summary effect size, $r = -0.53$. Heterogeneity in the effect sizes can be seen

by the lack of overlap of the confidence intervals for the different studies. Effect sizes ranged from -0.02 (a negligible effect), to -0.80 (a large effect).

Figure 4

Association between BMI and body distortion/perception



Publication bias. Visual inspection of the funnel plot indicates that there might be some studies missing from the plot (see Appendix E Figure E4). To confirm that there is asymmetry of this plot, Duval and Tweedie's trim-and-fill technique was used. Based on the results, no studies were added the funnel plot (see Appendix E Figure E4; see Table 10); suggesting that the sample of included studies is theoretically representative of the literature even if studies were missed during the search process.

Table 10

Results of Duval and Tweedie's trim-and-fill for the random-effects model of the association between body distortion/perception and BMI.

	Studies Trimmed	Point Estimate	LL	UL	*Q*-value
Observed values		-0.53	-0.59	-0.47	885.87
Adjusted values	0	-0.53	-0.59	-0.47	885.87

Note. LL = lower limit; UL = upper limit

Weight Satisfaction

Table 11

Summary of meta-analytic results of the association between BMI and weight satisfaction

	Weight satisfaction
Heterogeneity (*Q*; *df*=15)	71.34*
Random-effects Mean (ES)	-0.40*
95% CI	-0.45: -0.34

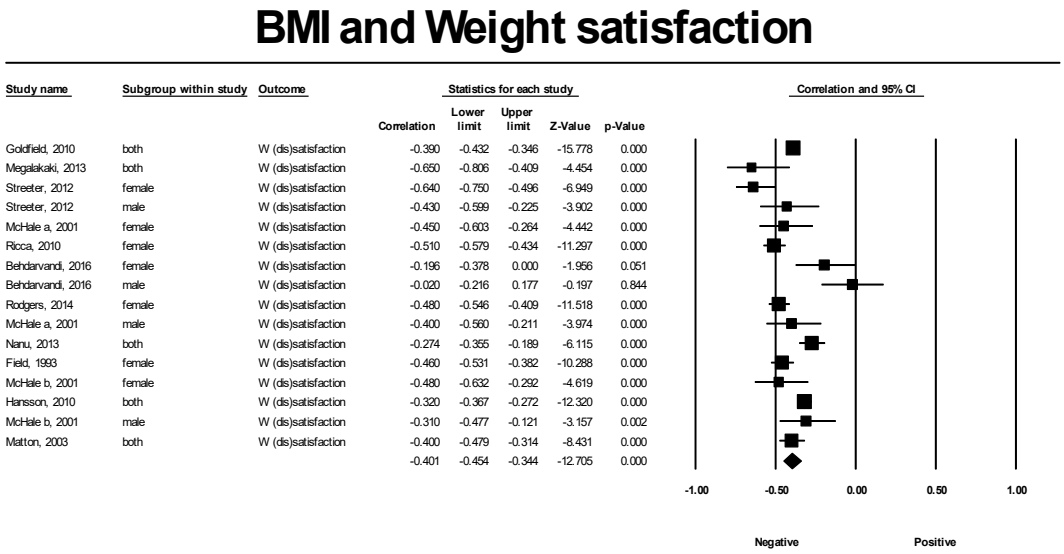
Note. ES = effect size.

*$p < .001$

Magnitude of the relationship. There was significant heterogeneity in the magnitude of the correlation between BMI and weight satisfaction (see Table 11). The average correlation between weight satisfaction and BMI was -0.40, which is a negative medium effect size, according to Cohen (1992). Figure 5 lists the studies included in this random-effects meta-analysis along with the distribution of their effect sizes around the summary effect size, $r = -0.40$. Heterogeneity in the effect sizes can be seen by the lack of overlap of the confidence intervals for the different studies. Effect sizes ranged from -0.02 (a negligible effect), to -0.65 (a large negative effect).

Figure 5

Association between BMI and weight satisfaction



Publication bias. Visual inspection of the funnel plot indicates that there might be some studies missing from the right side of the plot (see Appendix E Figure E5). To confirm that there is asymmetry of this plot, Duval and Tweedie's trim-and-fill technique was used. Based on the results, two imputed effect sizes were added to the right side of the funnel plot (see Appendix E Figure E6). The addition of these imputed studies resulted in a reduction in the effect size between weight satisfaction and BMI of -0.38 (see table 12).

Table 12

Results of Duval and Tweedie's trim-and-fill for the random-effects model of the association between weight satisfaction and BMI

	Studies Trimmed	Point Estimate	LL	UL	*Q*-value
Observed values		-0.40	-0.45	-0.34	71.34
Adjusted values	2	-0.38	-0.43	-0.32	87.34

Note. LL = lower limit; UL = upper limit

Body Image

Table 13

Summary of meta-analytic results of the association between BMI and body image

	Body image
Heterogeneity (*Q*; *df*=19)	196.26*
Random-effects Mean (ES)	-0.30*
95% CI	-0.38: -0.22

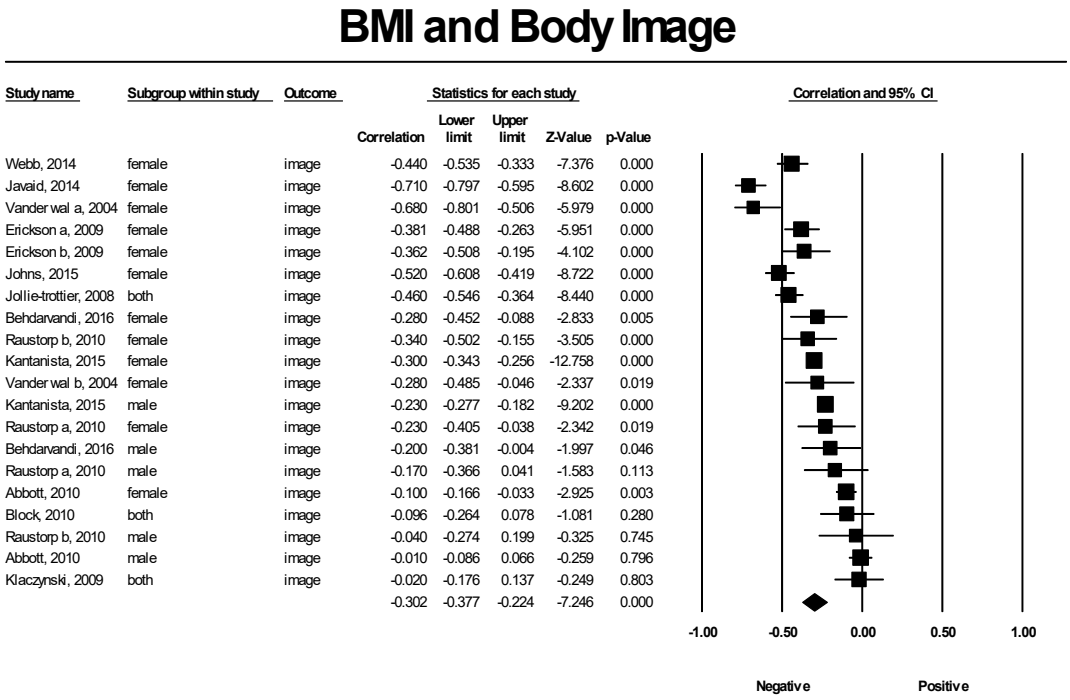
Note. ES = effect size.

*$p < .001$

Magnitude of the relationship. There was significant heterogeneity in the magnitude of the correlation between BMI and body image (see Table 13). The average correlation between body image and BMI was -0.30, which is a negative medium effect size, according to Cohen (1992). Figure 6 lists the studies included in this random effect meta-analysis along with the distribution of their effect sizes around the summary effect size, $r = -0.30$. Heterogeneity in the effect sizes can be seen by the lack of overlap of the confidence intervals for the different studies. Effect sizes ranged from -0.01 (a negligible effect), to -0.71 (a large effect).

Figure 6

Association between BMI and body image



Publication bias. Visual inspection of the funnel plot indicates that there might be some studies missing from the left side of the plot (see Appendix E Figure E7). To confirm that there is asymmetry of this plot, Duval and Tweedie's trim-and-fill technique was used. Based on the results, three imputed effect sizes were added to the left side of the funnel plot (see Appendix E Figure E8). The addition of these imputed studies resulted in an increase in effect size between body image and BMI of -0.35 (see table 14).

Table 14

Results of Duval and Tweedie's trim-and-fill for the random-effects model of the association between body image and BMI.

	Studies Trimmed	Point Estimate	LL	UL	*Q*-value
Observed values		-0.30	-0.38	-0.22	196.26
Adjusted values	3	-0.35	-0.43	-0.26	357.43

Note. LL = lower limit; UL = upper limit

Subgroup Analyses for each Body Image Subgroup

Trends in effect sizes suggest that there may be differences in effect sizes based on the sex of the sample for each body image subgroup. Subgroup analyses demonstrated that there are significant sex differences in the association between BMI and appearance satisfaction (with effect sizes for female samples being 1.75 times larger than studies with males and studies with both sexes), weight satisfaction (with effect sizes for females samples being 1.5 times larger than studies with males and studies with both), and body image (with effect sizes for females samples being 3 times larger than males; see Table 15). There were no significant sex differences for the association between BMI and body distortion (see Table 15; see Appendix F Figures F3-F6). It is important to highlight that while there are no official cut-offs for testing subgroups in meta-analysis, Card (2015) does suggest that five cases may be adequate to provide reliable results for moderator analyses. Therefore, the subgroup analyses for weight satisfaction and body image should be interpreted with caution as these results may be under-powered.

Table 15

Sex differences in the association between body image subgroups and BMI

	Body image subgroups			
	Appearance satisfaction	Weight satisfaction	Body image	Body distortion/perception
Sex ($Q_{b(1)}$)	9.31*	8.33*	8.06*	1.85
Both	-0.23** (*k*=11)	-0.37** (*k*=5)	-0.21 (*k*=3)	-0.45** (*k*=11)
Female	-0.42** (*k*=15)	-0.47** (*k*=7)	-0.39**(*k*=12)	-0.57** (*k*=16)
Male	-0.24** (*k*=7)	-0.29** (*k*=4)	-0.13 (*k*=5)	-0.53** (*k*=6)

Note. Both =studies with males and females

**$p < .001$.* $p < .05$.

Meta-Regression for each Body Image Subgroup

To try to explain some of the heterogeneity between studies within each construct, meta-regression analyses were run to determine if study quality and average age of participants significantly predicted the association between BMI and each body image construct (i.e., appearance satisfaction, weight satisfaction, body distortion, body image). The results indicated that age and study quality were not significant predictors of the association between appearance satisfaction, body distortion, weight satisfaction and BMI. However, for general body image, mean age of participants and study quality explained 61% of the between-study variance (R^2analog = 0.61, $Q(2) = 26.86$, $p = 0.000$). As the mean age of study participants increased, the correlation between body image and BMI decreased ($b = -0.055$, $se = 0.012$, 95% CI [-0.077, -0.032], $p < 0.001$). As study quality increased, the correlation between body image and BMI decreased ($b = -0.098$, $se = 0.029$, 95% CI [-0.154, -0.041], $p = 0.0007$).

Summary body image and BMI. Overall, the correlation between body image and BMI was moderate and suggests that those with a higher BMI have lower body image. Due to the heterogeneity among studies, body image studies were divided into more specific constructs of appearance satisfaction, weight satisfaction, body distortion, and general body image. The largest correlation was between BMI and body distortion followed by weight satisfaction, body image, and appearance satisfaction (according to trim-and-fill results). Subgroup analyses suggest that studies that included female samples only produced larger correlations between appearance satisfaction, weight satisfaction, and body image and BMI compared to studies that included male samples, or both male and female samples. There did not appear to be any sex differences in studies that examined body distortion and BMI. Finally, meta-regression analyses indicated that the mean age of the sample and study quality were associated with the correlation between body image and BMI. Studies that included older youth and higher study quality ratings on average, reported smaller correlations between body image and BMI.

A secondary aim of Study 1 was to determine the overall association between BMI and disordered eating behaviour. Therefore, a variety of disordered eating tools and constructs were included in this meta-analysis. Upon coding the studies, it was discovered that these disordered eating terms (e.g., emotional, restrained, external, and binge eating, unhealthy weight control behaviours) may be heterogenous. Therefore, I will present an overall association of BMI and disordered eating that pools effect sizes across constructs, but the remainder of this meta-analysis will be focused on the subcategories of disordered eating that were identified.

Disordered eating

Table 16 provides a summary of the meta-analysis results of the association between disordered eating and BMI. There was significant heterogeneity in the magnitude of the correlation between BMI and disordered eating (see Table 16). If a study used more than one measure of disordered eating, the effect sizes were combined to give an average effect size for that study. The results for the random-effects meta-analysis of the association between BMI and disordered eating are presented first, followed by subgroup analyses, and an examination of moderators of the effect size.

Table 16

Summary of meta-analytic results of the association between BMI and disordered eating

	Disordered eating
Heterogeneity (Q; df=69)	715.61*
Random-effects Mean (ES)	0.20*
95% CI	0.16; 0.24

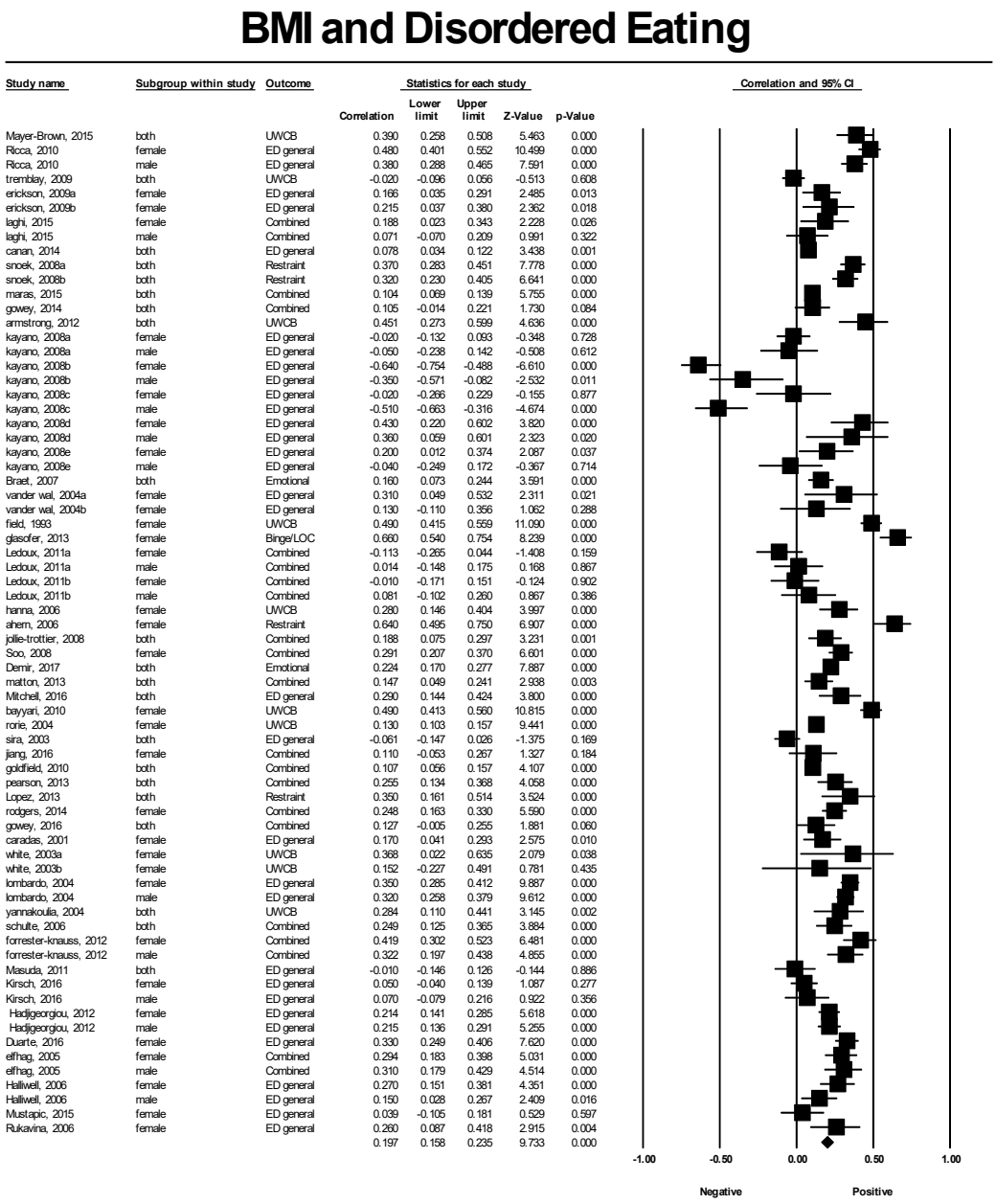
Note. ES = effect size.

*p< .001

Magnitude of the relationship. Disordered eating was expected to be positively associated with BMI. Overall, the average correlation between disordered eating and BMI was 0.20, which is a small positive effect size, according to Cohen (1992). Figure 7 lists the studies included in this random-effects meta-analysis along with the distribution of their effect sizes around the summary effect size, r = 0.20. Heterogeneity in the effect sizes can be seen by the lack of overlap of the confidence intervals for the different studies and the range of effect sizes from negative to positive. Effect sizes ranged from -0.64 (a large negative effect), to 0.66 (a large positive effect).

Figure 7

Association between disordered eating and BMI



Publication bias. Visual inspection of the funnel plot indicates that there might be some studies missing from the left side of the plot (see Appendix E Figure E9). To

confirm that there is asymmetry of this plot, Duval and Tweedie's trim-and-fill technique was used. Based on the results, 12 imputed effect sizes were added to the left side of the funnel plot (see Appendix E Figure E10). The addition of these imputed studies resulted in a decrease in effect size between disordered eating and BMI of 0.14 (see table 17). Importantly, the 'missing' effect sizes in this subsection of the meta-analysis are likely the result of a lack of cross-cultural research on disordered eating, not a failing of the search strategy used. It is possible that a large number of studies are not missing from the search. Rather, these studies do not exist. Therefore, the 'observed' values of the disordered eating section of this meta-analysis may be more representative of current research than the 'adjusted' values.

Table 17

Results of Duval and Tweedie's trim-and-fill for the random-effects model of the association between disordered eating and BMI.

	Studies Trimmed	Point Estimate	LL	UL	*Q*-value
Observed values		0.20	0.16	0.24	715.61
Adjusted values	12	0.14	0.09	0.18	1125.18

Note. LL = lower limit; UL = upper limit

Subgroup analyses. While the trends in effect sizes suggest that there is stronger association between disordered eating and BMI for females, subgroups analyses demonstrated no significant differences between groups (see Table 18; Appendix F Figure F7). This data were also coded for construct as it was expected that the type of disordered eating that was measured will have a significantly different association with BMI (see Table 18; Appendix F Figure F8). Therefore, construct subgroups were analyzed separately.

Table 18

Sex differences in the association between disordered eating and BMI

	Sex differences in disordered eating
Sex ($Q_{b(1)}$)	5.31
Both (k=21)	0.19**
Female (k=34)	0.24**
Male (k=15)	0.11*

*p < .05. **p < .001.

Subgroup analyses suggest that there are differences in effect sizes based on the construct that was measured (see Table 19). Studies that measured binge eating or restrained eating demonstrated the largest correlations with BMI, followed by unhealthy weight control behaviours, general eating disorder symptoms, emotional eating, and external eating. Due to the large differences in effect sizes between constructs, studies were divided by construct and examined separately (see Appendix D for definitions). To better focus the results of this meta-analysis, only the results for restrained, emotional, and external eating are presented in the main text as they are the focus of Study 2. The results for the remaining disordered eating constructs (i.e., binge eating, unhealthy weight control behaviours, and general eating disorders) are presented in Appendix G.

Table 19

Construct differences in the association between disordered eating and BMI

	Construct associations with BMI
Construct ($Q_{b(1)}$)	80.06**
Binge/LOC (k=5)	0.36**
General eating disorder(k=35)	0.13**
Emotional (k=18)	0.08*
External (k=10)	-0.09

	Construct associations with BMI
Restrained (*k*=20)	0.35**
UWCB (*k*=14)	0.29**

Note. Unhealthy weight control behaviours (UWCB); Binge = binge eating; LOC = loss of control eating; Emotional = emotional eating; External = external eating; Restrained = restrained eating.
*$p < .05$. **$p < .001$

Restrained/Restrictive Eating

To help simplify the language moving forward, the construct of restrained/restrictive eating will be referred to as restrained eating. Table 20 provides a summary of the meta-analysis results of the association between restrained eating and BMI. There was significant heterogeneity in the magnitude of the correlation between BMI and restrained eating (see Table 20). The results for the random-effects meta-analysis of the association between BMI and restrained eating are presented first, followed by the remaining construct results (i.e., emotional and external eating), and an examination of subgroups and moderators of the effect sizes of each subgroup.

Magnitude of the relationship. The average correlation between restrained eating and BMI was 0.35, which is a positive medium effect size, according to Cohen (1992). Figure 8 lists the studies included in this random-effects meta-analysis along with the distribution of their effect sizes around the summary effect size, $r = 0.35$. Heterogeneity in the effect sizes can be seen by the lack of overlap of the confidence intervals for the different studies. Effect sizes ranged from 0.06 (a negligible effect), to 0.64 (a large effect).

Table 20

Summary of meta-analytic results of the association between BMI and restrained eating

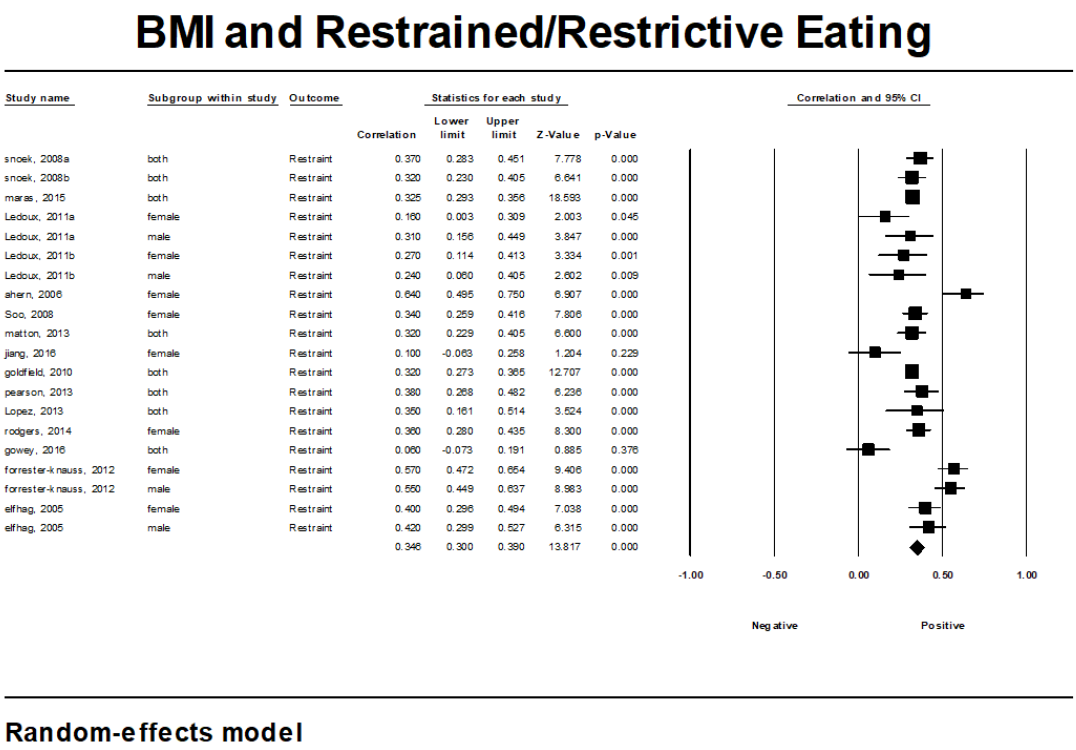
	Restrained Eating
Heterogeneity (*Q*; *df*=19)	88.79*
Random-effects Mean (ES)	0.35*
95% CI	0.30: 0.39

Note. ES = effect size.

*$p < .001$

Figure 8

Association between Restrained eating and BMI



Publication bias. Visual inspection of the funnel plot indicates that there might be some studies missing from the right side of the plot (see Appendix E Figure E11). To confirm that there is asymmetry of this plot, Duval and Tweedie's trim-and-fill technique

was used. Based on the results, five imputed effect sizes were added to the right side of the funnel plot (see Appendix E Figure E12). The addition of these imputed studies resulted in an increase in effect size between restrained eating and BMI of 0.39 (see table 21).

Table 21

Results of Duval and Tweedie's trim-and-fill for the random-effects model of the association between restrained eating and BMI.

	Studies Trimmed	Point Estimate	LL	UL	*Q*-value
Observed values		0.35	0.30	0.39	88.79
Adjusted values	5	0.39	0.34	0.44	163.89

Note. LL = lower limit; UL = upper limit

Emotional Eating

Table 22

Summary of meta-analytic results of the association between BMI and emotional eating

	Emotional eating
Heterogeneity (*Q*; *df*=17)	89.43*
Random-effects Mean (ES)	0.08*
95% CI	0.03: 0.14

Note. ES = effect size.

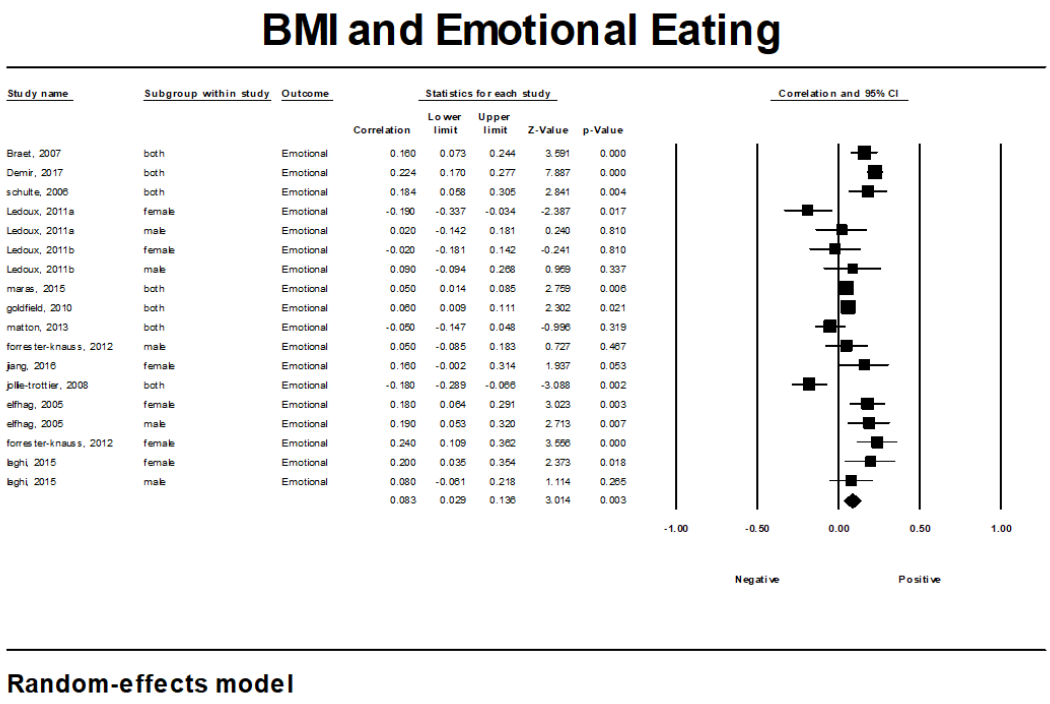
*$p < .001$

Magnitude of the relationship. There was significant heterogeneity in the magnitude of the correlation between BMI and emotional eating (see Table 22). The average correlation between emotional eating and BMI was 0.08, which is a minimal or negligible effect size, according to Cohen (1992). Figure 9 lists the studies included in this random-effects meta-analysis along with the distribution of their effect sizes around

the summary effect size, $r = 0.08$. Heterogeneity in the effect sizes can be seen by the lack of overlap of the confidence intervals for the different studies. Effect sizes ranged from -0.19 (a small negative effect), to 0.24 (a small positive effect).

Figure 9

Association between emotional eating and BMI



Publication bias. Visual inspection of the funnel plot indicates that there might be some studies missing from the left side of the plot (see Appendix E Figure E13). To confirm that there is asymmetry of this plot, Duval and Tweedie's trim-and-fill technique was used. Based on the results, one imputed effect size was added to the left side of the funnel plot (see Appendix E Figure E14). The addition of this imputed study resulted in a decrease in effect size between emotional eating and BMI of 0.07 (see table 23).

Table 23

Results of Duval and Tweedie's trim-and-fill for the random-effects model of the association between emotional eating and BMI

	Studies Trimmed	Point Estimate	LL	UL	*Q*-value
Observed values		0.08	0.03	0.14	89.43
Adjusted values	1	0.07	0.02	0.13	96.17

Note. LL = lower limit; UL = upper limit

External Eating

Table 24

Summary of meta-analytic results of the association between BMI and external eating

	External Eating
Heterogeneity (*Q*; *df*=9)	47.87*
Random-effects Mean (ES)	-0.09*
95% CI	-0.16: -0.02

Note. ES = effect size.

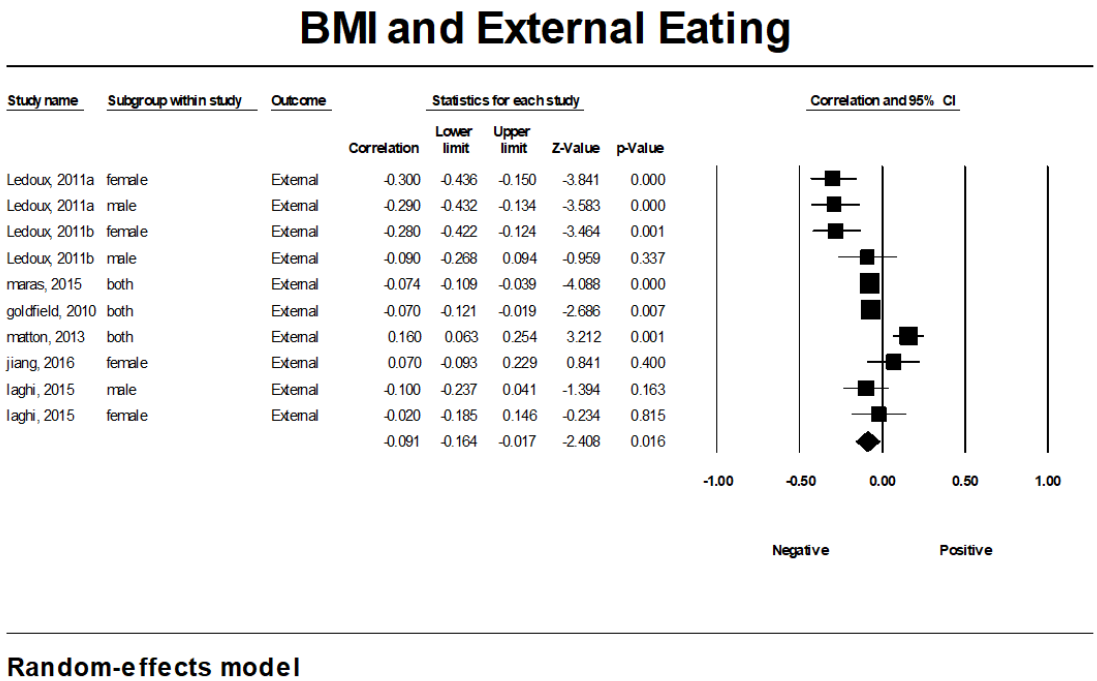
*$p < .001$

Magnitude of the relationship. There was significant heterogeneity in the magnitude of the correlation between BMI and external eating (see Table 24). There was no expectation for the direction of the correlation between external eating and BMI due to the inconsistencies in the research. Overall, the average correlation between external eating and BMI was -0.09, which is a negative small negligible effect size, according to Cohen (1992). Figure 10 lists the studies included in this random-effects meta-analysis along with the distribution of their effect sizes around the summary effect size, $r = -0.09$. Heterogeneity in the effect sizes can be seen by the lack of overlap of the confidence

intervals for the different studies. Effect sizes ranged from -0.30 (a medium negative effect), to 0.16 (a small positive effect).

Figure 10

Association between BMI and external eating



Publication bias. Visual inspection of the funnel plot indicates that the plot looks relatively symmetrical. To confirm that there is symmetry of this plot, Duval and Tweedie's trim-and-fill technique was used. Based on the results, no additional effect sizes were added to the funnel plot (see Appendix E Figure E15).

Subgroup Analyses for Disordered Eating

While the trends in effect sizes suggest that there may be differences in effect sizes based on the sex of the sample for each construct, subgroup analyses demonstrate no significant differences between groups for each disordered eating construct (see Table 25; see Appendix F Figures F9 & F10).

Table 25

Sex differences in effect size between disordered eating subgroups

	Disordered eating		
	Restrained	Emotional	External
Sex ($Q_{b(1)}$)	2.15	0.25	-
Both	0.31* (k=8)	0.07 (k=7)	-
Female	0.36* (k=8)	0.10 (k=6)	-
Male	0.40* (k=4)	0.09 (k=5)	-

Note. There were too few studies in the external eating category to test subgroups ($k < 5$).
*$p < .001$

Meta-regression for each Disordered Eating Subgroup

To try to explain some of the heterogeneity between studies within each construct, meta-regression analyses were run to determine if study quality and average age of participants significantly predicted the association between BMI and each disordered eating construct (i.e., emotional, restrained, and external eating). The results indicated that age and study quality were not significant predictors of the association between emotional eating, restrained eating, or external eating and BMI.

Summary: Disordered eating and BMI. Overall, the correlation between disordered eating and BMI was small but suggests that those with higher BMIs have higher rates of disordered eating behaviours. Due to the heterogeneity among studies, disordered eating was divided into more specific constructs of restrained, external, emotional, binge, unhealthy weight control behaviours, and general eating disorder symptoms. The largest correlation was between BMI and binge eating followed by restrained eating, unhealthy weight control behaviours, general eating disorder

symptoms, external, and emotional eating. The main results focused on restrained, emotional, and external eating as these are the disordered eating constructs that were examined in Study 2 of this thesis. Trim-and-fill procedures indicated that the correlation between emotional eating and BMI was slightly smaller, and the correlation between restrained eating and BMI was slightly larger. Subgroup analyses suggested that there were no sex differences in the correlations between restrained, emotional, or external eating and BMI.

Quality of life

Table 26 provides a summary of the meta-analysis results of the association between quality of life and BMI. There was significant heterogeneity in the magnitude of the correlation between BMI and quality of life (see Table 26). If a study used more than one measure of quality of life, the effect sizes were combined to give an average effect size for that study.

Table 26

Summary of meta-analytic results of the association between BMI and quality of life

	Quality of life
Heterogeneity (Q; df=20)	190.42*
Random-effects Mean (ES)	-0.22*
95% CI	-0.28; -0.16

Note. ES = effect size.

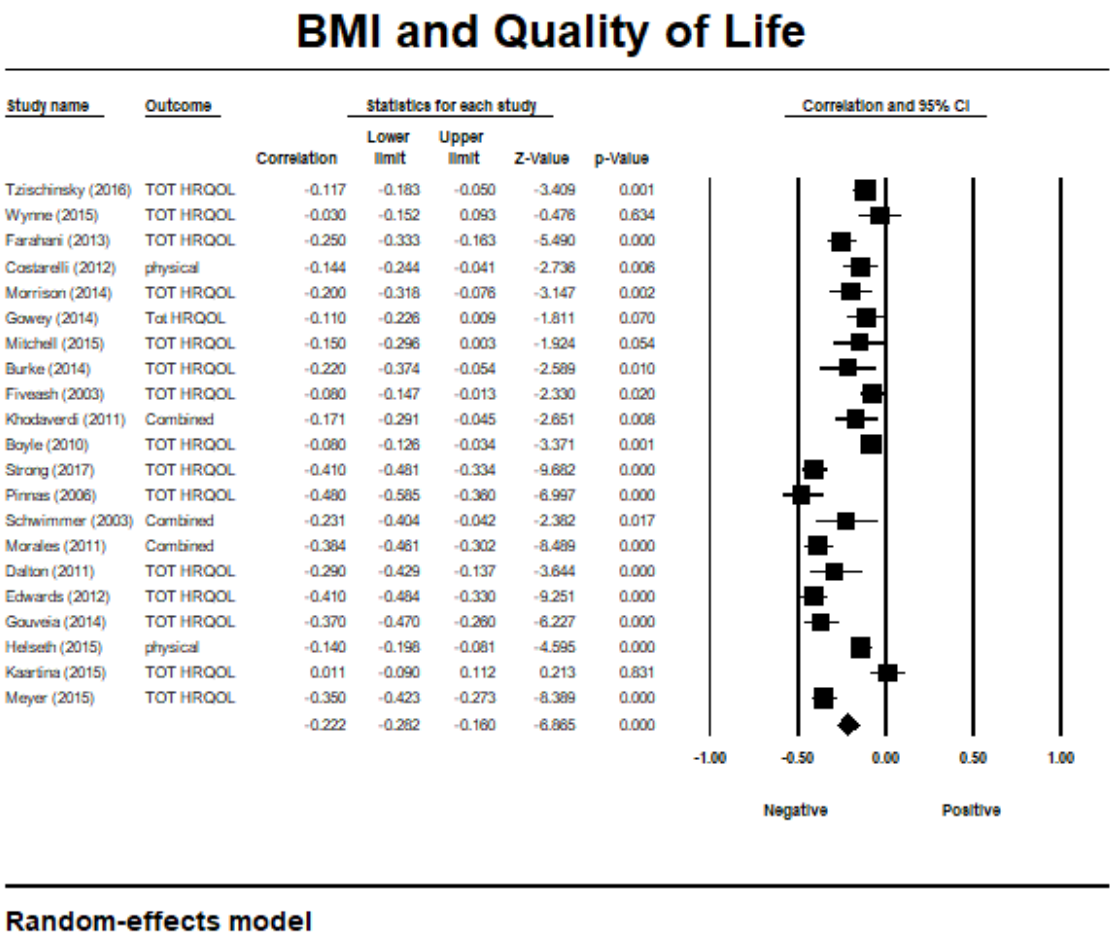
*$p < .001$

Magnitude of the relationship. The average correlation between quality of life and BMI was -0.22 (see Table 26), which is a small negative effect size, according to Cohen (1992). Figure 11 lists the studies included in this random-effects meta-analysis along with the distribution of their effect sizes around the summary effect size, r = -0.22.

Heterogeneity in the effect sizes can be seen by the lack of overlap of the confidence intervals for the different studies and the range of effect sizes -0.48 to 0.01.

Figure 11

Association between quality of life and BMI



Publication bias. Visual inspection of the funnel plot indicates that studies are distributed relatively symmetrically (see Appendix E Figure E16). To confirm that there is symmetry of this plot, Duval and Tweedie's trim-and-fill technique was used (see Table 27). Based on the results, zero imputed effect sizes were added to the funnel plot (see Appendix E Figure E16).

Table 27

Results of Duval and Tweedie's trim-and-fill for the random-effects model of the association between quality of life and BMI.

	Studies Trimmed	Point Estimate	LL	UL	*Q*-value
Observed values		-0.22	-0.28	-0.16	190.42
Adjusted values	0	-0.22	-0.28	-0.16	190.42

Note. LL = lower limit; UL = upper limit

Subgroup analyses for Quality of Life

While sex differences were examined for the other constructs of body image and disordered eating, the quality of life studies that were included in this meta-analysis all consisted of samples with approximately similar number of males and females and did not provide the correlations for males and females separately. Therefore, no sex subgroup analyses were examined. This data was not coded for construct as most studies reported a total quality of life score.

Meta-regression for Quality of Life

To try to explain some of the heterogeneity between quality of life studies, meta-regression analyses were run to determine if study quality and average age of participants significantly predicted the association between BMI and quality of life. The results indicated that age and study quality were not significant predictors of the association between quality of life and BMI.

Summary quality of life and BMI. Overall, the correlation between quality of life and BMI was smaller than expected but still suggests that people with higher BMIs report poorer quality of life. Subgroup analyses were not computed as all of the studies examined an approximately even number of males and females. Lastly, meta-regression analyses did not reveal any significant moderators of this association.

Discussion

The purpose of this meta-analysis was to determine the overall association between BMI and health outcomes in community samples of children and youth to provide insight into if and how, BMI is related to body image, disordered eating, and quality of life. Additionally, subgroups (i.e., sex, construct), and moderators (i.e., age, study quality) were examined to see if they could explain the variability in effect sizes. It was expected that higher BMI would be associated with lower body image, higher disordered eating, and lower quality of life.

Body image and BMI

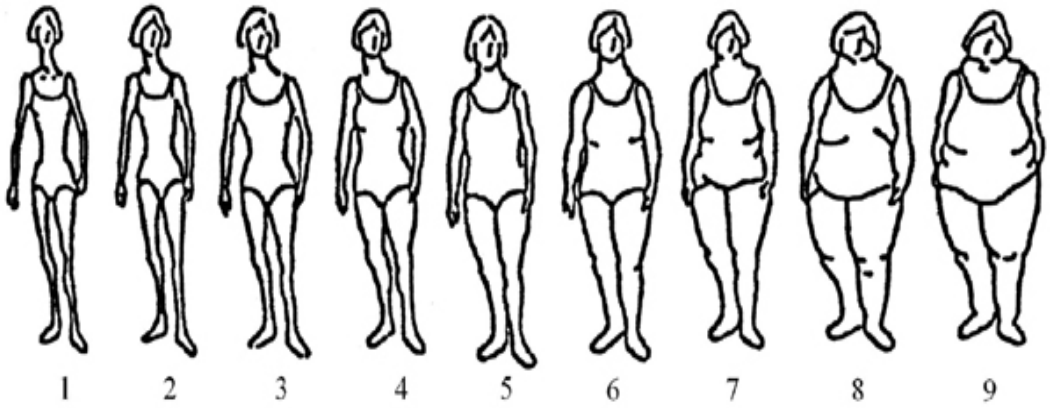
As expected, body image was significantly negatively related to BMI in this meta-analysis. While effect sizes varied in magnitude, all forms of body image were negatively associated with BMI. These findings are consistent with two recent meta-analyses with adults (He et al., 2020; Weinberger et al., 2016) that found that adults with higher BMIs are more likely to report lower body image. Overall, the sex differences between boys and girls were in agreement with adult findings where studies that examine females samples, demonstrate a stronger association between BMI and body dissatisfaction (Weinberger et al., 2016) and less body appreciation than males (He et al., 2020). There were, however, three novel findings in the body image subsection of this study: 1) significant differences in effect sizes based on the sub-category of body image being measured; 2) absence of sex differences in the association between BMI and body distortion scores and; 3) lower correlation of the body image subcategory with BMI.

There are a number of ways to assess body image. Most body image measures (e.g., appearance and weight satisfaction, general body image) include Likert scale

responses to written statements (e.g., “I have a nice body”), while other measures use visual comparisons. Arguably, the most unique assessment is for body distortion. To measure body distortion, researchers use visuals (i.e., silhouette or figure rating scales; see Figure 12; Stunkard et al., 1983) and ask participants which figure looks the most like them, followed by asking participants which figure looks the most like their ideal body. Each participant receives a discrepancy score based on the extent to which their current figure differs from their ideal figure.

Figure 12

Female images of the Figure Rating Scale (Stunkard et al., 1983)



In this meta-analysis, body distortion was the most strongly related to BMI. This was interesting as there could be a few plausible reasons for this finding. First, it might be a more objective measure of body image. It is possible that the simplicity of choosing figures to represent your current and ideal body do not allow for different interpretations of the question, while a Likert scale question of “*I like what I weigh*” can allow for different interpretations based on the individual. For example, one person may be okay with their weight but does not like their body shape which would result in different answers to the same Likert scale question. On the other hand, the nature of this type of

measurement might be contributing to the inflated effect size. It is possible that this type of measurement is naturally biased because participants may feel that since researchers are asking two different questions about the same photos, the two questions should yield different answers. This type of questionnaire could be particularly confusing for young children since they may not have the agency to ask if they can pick the same image for their current and ideal body types. Additionally, it might be harmful to ask about an 'ideal' body type as it suggests to children that there is an 'ideal' body type that they should aspire to, and children who do not see themselves represented by any of the figures may wonder if there is something wrong with their body. Finally, figure rating scales may not truly represent body image in general. Current research about body acceptance and appreciation claims that it is possible to want an ideal body that is different from your own and simultaneously, be content with your current body (He et al., 2020; Tiggemann, 2015). Future research should examine the intricacies of figure rating scales compared to questionnaire measures of body image to clarify the link between body image and BMI. Researchers could begin with forming focus groups with people of different ages and sexes to determine how they interpret different body image measures.

Interestingly, body distortion was the only construct that did not reveal any sex differences, suggesting that males and females report similar negative associations between body distortion and BMI. It is possible that this is due to the more 'objective' nature of the question. Youth (males and females) with bigger bodies will choose a larger figure that matches their own to represent their current body (even if they slightly underestimate their weight; Steinsbekk et al., 2017), but they will likely choose an ideal body that is smaller or different than the body they are in, especially if they have had

consistent exposure to idealized images. However, with a common questionnaire item of "I want to look thinner" females may endorse this item but males may not want to look thinner resulting in sex differences in the association between BMI and body image Likert scale questions. Therefore, the association between BMI and body distortion scores are likely to be more similar among males and females than associations between BMI and Likert items of body image.

There has been extensive research on the relevancy of body image questionnaire items for males, and more recently, researchers have attempted to develop questions that are more related to the ideal body changes that males strive for (i.e., muscularity; McCreary et al., 2007). A recent meta-analysis on sex differences in body dissatisfaction over time found that men report higher scores on muscularity-oriented body dissatisfaction, while women report higher scores on thinness-oriented body dissatisfaction (Karazsia et al., 2017). There were limited studies that used the muscularity-based questionnaire in the present meta-analysis, making it difficult to examine this difference in Likert scale items.

The association between body image and BMI was moderate suggesting that youth with higher BMIs do indeed have lower body image. While this effect is not particularly surprising, it is interesting that the association between BMI and the body image sub-category was not as strong as the association between BMI and the other body image outcomes such as weight satisfaction and body distortion, even though it is arguably the most holistic measure of body image. Additionally, this is the only construct that appears to vary by age. Studies that included older adolescents, on average, reported smaller correlations between body image and BMI. It is possible that the age association

is due to the fact that the lower end of the age spectrum was around the age of puberty, perhaps the most difficult time for body image in youth. Research with adult samples has found that older women report more body appreciation (Tiggemann and McCourt, 2013), and that there do not appear to be age differences in body appreciation among men (Swami et al., 2016). Therefore, these differences could apply to older teenagers as well.

Disordered Eating and BMI

Youth with higher BMI scores reported more disordered eating behaviours. There were three key findings related to disordered eating and BMI: 1) restrained eating appeared to be the only type of disordered eating that was strongly related to BMI; 2) emotional eating may not be as common among youth with overweight and obesity as society suggests it is and; 3) external eating may need to be re-evaluated as a measure of disordered eating.

Consistent with past research, restrained eating was positively associated with BMI (Snoek et al., 2013). Research has demonstrated that youth with higher average weight are more likely to engage in restrained eating because they are bombarded with messages from parents, friends, health professionals, and the media that they are too heavy and could remedy this by eating less (Epstein & Ogden, 2005; Fouts & Burggraf, 1999; Greenberg et al., 2003; Puhl et al., 2008; Puhl et al., 2009). This can lead to extreme restraint that can be followed by binge episodes. Restrained and binge eating are problematic, especially for youth with obesity as they can exacerbate this disease and potentially lead to increased weight (Braet et al., 2008; Polivy & Herman, 1985; Stice, 2001). These findings echo past research that restrained eating is more common in people with higher BMIs (Snoek et al., 2013). Therefore, it is important that clinicians and

researchers encourage intuitive eating in youth (e.g., responding to hunger and satiety cues) as any form of restrained eating can damage metabolic functioning, lead to episodes of binge eating, and increased weight (Herman & Polivy, 1980; Neumark-Sztainer, Wall, et al., 2007; Sumithran et al., 2011).

Emotional eating was also associated with BMI but the effect size was considered negligible according to Cohen's (1992) standards. Past research has found conflicting results related to emotional eating and BMI (Belcher et al., 2011; Goldfield et al., 2010; Parkinson et al., 2010; Snoek et al., 2013). Certainly current weight stigma norms suggest that youth with overweight or obesity are more likely to eat in response to their emotions compared to their average weight peers (Puhl et al., 2009). Based on the results of this meta-analysis, it appears that this is not the case and that there is no clear association between emotional eating and BMI.

The assumption that people with obesity are more likely to engage in emotional eating is largely rooted in weight stigma (Puhl et al., 2009). For years, the media has suggested that people with obesity are likely to engage in unhealthy eating in response to their emotions. However, it is possible that youth with overweight or obesity are hyper-aware of their size and overly cautious when it comes to emotional eating. This does not mean that emotional eating is not an important construct for overall health; research has found associations between emotional eating and poor mental health (Goossens et al., 2009) and disordered eating (Braet et al., 2008). However, it is important that cultural norms around obesity and eating behaviours begin to shift to reduce the amount of weight stigma experienced by youth and adults, as it can lead to poor mental health, and lower quality of life (Emmer et al., 2020; Papadopoulos & Brennan, 2015; Wu & Berry, 2018).

External eating was not significantly associated with BMI. This finding is also contrary to weight stigma assumptions that suggest that people with overweight and obesity cannot control their urge to eat when faced with food (Allison et al., 1991; Puhl et al., 2010). The connection between external eating and BMI has been unclear, some researchers have found that higher external eating is related to lower BMI (Goldfield et al., 2010; Snoek et al., 2007); other research has found no link between the two constructs (Ledoux et al., 2011). The association between weight status and external eating might be an important avenue for future research. Determining the intricacies of this type of eating, and how and if it relates to BMI could help clinicians better understand eating behaviours in youth with higher average weight and guide prevention programs.

Quality of Life and BMI

Having a higher BMI was associated with lower quality of life scores. While this finding is consistent with public health recommendations and treatment for obesity (Fontaine & Barofsky, 2001; Ul-Haq et al., 2013; Wharton et al., 2020), the overall correlation was smaller than expected. This result suggests that the association between BMI and total quality of life is not as prominent as the literature would suggest or the total score for quality of life may obscure the specific areas where BMI has the most negative impact (i.e., physical health).

In the present meta-analysis, the total quality of life scores consisted of physical, emotional, social, and school related difficulties. This is a fairly broad definition of quality of life in children and youth. One explanation for this is that youth living at higher weights are not ‘doomed’ to have poor quality of life. Rather, it is possible that youth

with obesity can have good physical, social, and emotional quality of life. Another possibility is that if the scores were disaggregated, only the physical quality of life subsection of the scale would yield a larger correlation due to the more direct impact of weight on physical well-being.

A meta-analysis of research with adult samples found that adults with higher BMIs had significantly lower physical health-related quality of life; however, significantly lower mental health scores were only present in the highest category of obesity (Ul-Haq et al., 2013). This suggests that mental health may be most impacted by BMI at the highest range of the BMI scale rather than incrementally across increased weight; while physical quality of life appears to decrease as BMI increases across the weight spectrum. It is possible that current measures of quality of life are not sensitive to the type of mental health struggles that are present for people with obesity. Future research should attempt to 'unpack' this construct, to 'fine tune' our knowledge about the relationship between BMI and specific aspects of quality of life in youth.

Strengths and Limitations

The present meta-analysis has some strengths that should be highlighted. First, the scope of this review was wide-reaching and comprehensive. While there are more databases that could have been searched, the present study included similar databases as previous meta-analyses in comparable research areas (He et al., 2020; Karazsia et al., 2017; Weinberger et al., 2016). Another strength is the exploratory nature of this study. Most meta-analyses only examine one construct or limited scales, the present study attempted to quantify a wide range of body image scores and scales to make

comparisons. While this is not common practice, it has allowed for some interesting findings especially within body image research.

There are some limitations that occurred during this comprehensive look at the literature. First, there were a lack of correlations presented in the research. One of the main reasons for study exclusion were the lack of correlations included in the articles. The majority of studies did not include correlation tables or in-text correlations between BMI and each outcome. Additionally, studies with more advanced statistical models only presented final model results and minimal descriptive information. Second, there may have been some databases missed due to the choices made by the researcher and restrictions based on the databases available at the university. However, this is not a major concern as the databases used are relatively common among other meta-analyses that have been completed to date (Gow et al., 2019; He et al., 2020; Weinberger et al., 2016). Third, there could have been an additional review of more recent research (until December 2020) that was not examined due to program completion limitations. A quick search of one of the larger and more inclusive databases suggests that there are approximately 116 papers that have been published since this search ended. A quick review of these articles indicates that almost half of these would be excluded based on their titles, alone (27 included clinical samples, 8 used an intervention method, 12 included adult samples, and 1 was a commentary). Therefore, it may be important to screen these remaining studies before attempting to publish this data. Finally, there was limited reporting of moderators in the selected papers. Originally, I planned to code for a number of variables that may impact the association between BMI and each outcome (e.g., weight categories, average BMI of sample). However, lack of consistent reporting

of key demographics across studies made it difficult to examine a wide variety of moderators. Ideally, future research will have more strict criteria around reporting of demographic characteristics to allow for further exploration of these associations.

Conclusion

This meta-analysis provides a comprehensive look at the association between BMI and health outcomes in youth. The correlation between body image and BMI varied significantly based on the construct measured, restrained eating appeared to be the main eating concern for youth with higher average weight, and quality of life was negatively correlated with BMI, but to a lesser extent than anticipated. Average age of the sample and study quality did not appear to have a large impact on any of the associations which may be due to the lack of variability within these variables. It is possible that zero-order correlations may not have revealed the full relationship between BMI and body image, disordered eating, and quality of life, and that these correlations are less pronounced due to the exclusion of studies that included treatment groups or clinical samples. However, this may be a good news story for community youth with higher BMIs as they do not appear to be as burdened by body image concerns, external and emotional eating, or quality of life as researchers and clinicians would assume. Further research is required to determine if these findings are more pronounced in clinical versus community samples, and if there is a better way to capture relevant mental health concerns that impact the quality of life of youth with obesity. The findings from this meta-analysis were informative for Study 2 of this dissertation as they provided more information on the importance of some of the key variables in the overall model, and helped explain any nonsignificant findings in the overall model of BMI and health outcomes.

Study 2: Longitudinal Model

In Study 2, I examined the impact of body esteem on health outcomes (i.e., disordered eating, quality of life, BMI) in youth living with severe obesity who are part of a hospital-based weight management program. Specifically, using latent growth curve modelling, I tested how each variable changed over time by examining the univariate trajectory of each variable, and how these variables changed together over time by examining bidirectional associations of these trajectories throughout two years in a pediatric weight management program. I controlled for sex, age at baseline, total appointments attended (to control for program engagement), and number of medical and mental health comorbidities. It was expected that there would be improvements in program outcomes of body esteem, disordered eating, and quality of life over time. Based on previous literature, it was hypothesized that: 1) those coming into the program with higher body esteem (i.e., at baseline) would have less disordered eating (i.e., emotional and restrained eating) and higher quality of life at baseline regardless of BMI; 2) patients with higher body esteem at baseline would have less disordered eating (i.e., emotional eating, restrained eating), and higher quality of life over time, regardless of BMI, and 3) it was expected that positive changes in body esteem would be related to enhanced outcomes (i.e., improved quality of life and less disordered eating) over time.

Participants

209 youth with severe complex obesity from 4 to 18 years old (M_{age} = 13.17, *SD* = 3.1; 95% of the sample was over the age of 8 at baseline; 70% were over the age of 12 at baseline) participated in this study (see Table 28). There were nearly equal numbers of boys and girls (53% female) in the study. The average baseline BMI was 37.24, and on

average, youth reported one mental health comorbidity, and one to two medical comorbidities. The average number of appointments attended over two years in treatment was 13. Participants were from a hospital-based weight management centre in Ottawa, Ontario. This study used an archival dataset that includes measures that youth and their parents completed during the first two years of the program.

Procedures

Permission was obtained from the Children's Hospital of Eastern Ontario's Research Ethics Board and the Carleton University Research Ethics Board to analyze the data. Participants provided verbal assent or written informed consent based on age of entry. Parental written consent was also provided to complete measures and to have the data available to inform research. Participants were administered questionnaires in person at baseline (assessment), and at 6 ,12, 18, and 24 month follow-up appointments. Results from questionnaires were anonymized after being entered into the dataset.

Participants in the program were physician referred, after meeting the program criteria: 1. Between the ages of 4 and 17; 2. BMI greater than 99th percentile or BMI greater than 95th percentile with an associated severe medical or psychosocial comorbidity or chronic illness that is impacted by obesity. This weight management program follows the Canadian Clinical Practice Guidelines for the Prevention and Management of Obesity. The Centre for Healthy Active Living (CHAL) is a two-year multidisciplinary program. CHAL uses a health at every size framework to improve the quality of life of children and youth living with obesity and their families by targeting eating behaviours, mental health, physical activity, family communication around health, and managing comorbidities. This program does not focus on BMI as a measure of

success but instead, celebrates improvements in mental health, eating behaviours, and quality of life.

Measures

In addition to demographic information, four constructs were examined using the following questionnaires (see Appendix H): body esteem (Body Esteem Scale for Adolescents and Adults; BESAA; Mendelson et al., 2001), disordered eating (Dutch Eating Behavior Questionnaire; DEBQ; Van Strien et al., 1986), quality of life (Pediatric Quality of Life scale; PedsQL; Varni et al., 2001) child and teen versions, and BMI (measured height and weight).

Demographics

Basic demographic data was collected for each participant. This included: sex, age, number of mental health and medical comorbidities, and program attendance/engagement (i.e., number of appointments attended).

Body Esteem Scale for Adolescents and Adults (BESAA)

The BESAA was used to assess adolescents feelings about their bodies and appearance. The BESAA includes three subscales: BE-Appearance esteem including general feelings about one's appearance (e.g., *I like what I look like in pictures*), BE-Weight esteem including weight satisfaction (e.g., *I like what I weigh*), and BE-Attribution esteem including evaluations attributed to others' opinions of one's appearance (e.g., *Other people consider me good looking*). The BE-Attribution subscale was not be used in the present study because of poor predictive validity (Cragun et al., 2013) and it does not include items that are appropriate for all ages (e.g. *My looks will help me get a job*). The BESAA is evaluated on a 5-point Likert scale ranging from 1

(*Never*) to 5 (*Always*). A high score on the BESAA subscales indicate high body esteem, and a low score indicates low body esteem. The BE-Appearance subscale had high internal consistency (Cronbach's α = .93) in the present sample. The BE-Weight subscale had good internal consistency (Cronbach's α = .89) in the present sample. Each subscale has high test-retest reliability in previous samples (Mendelson et al., 2001).

Pediatric Quality of Life scale (PedsQL) child, and teen versions

The PedsQL assesses quality of life in children from ages 8-12 (child) and 13-18 (adolescent). It includes four subscales: physical functioning (e.g., *It is hard for me to walk more than one block*), emotional functioning (e.g., *I feel sad or blue*), social functioning (e.g., *I have trouble getting along with other kids*), and school functioning (e.g., *It is hard to pay attention in class*; Varni et al., 2001). The PedsQL is evaluated on a 5-point Likert scale ranging from 0 (*Never*) to 4 (*Always*). Once measures are completed these scores are transformed to values of 0 (*Never*), 25, 50, 75, 100 (*Always*). Each subscale has an average score ranging from 0 to 100. For the present study, a total score was used to measure overall quality of life. A higher total score indicates that an individual feels like they have a good quality of life. Lower scores indicate that the individual feels that they have a poorer quality of life. The PedsQL has demonstrated good reliability and internal consistency for the total score (Cronbach's α =.88) in previous samples (Varni et al., 2001). In addition, the PedsQL is able to distinguish between 'healthy' children and children with acute or chronic conditions (Varni et al., 2001).

Dutch Eating Behavior Questionnaire (DEBQ)

The DEBQ was used to assess restrained, emotional, and external eating behaviour. This scale addresses the types of disordered eating behaviours that are present in youth with obesity. Restrained eating involves restricting one's self from eating food to lose weight (e.g., *If you have put on weight, do you eat less than you usually do?*). Emotional eating is when an individual eats to avoid or deal with their negative emotions (e.g., *Do you have a desire to eat when you are irritated?*). External eating happens when an individual eats in response to external cues rather than internal feelings of hunger (*e.g., If you see others eating, do you have a desire to eat?*). Each of these types of disordered eating behaviours can increase the likelihood of weight gain in youth. Participants indicate the degree to which each statement applies to them on a 5-point Likert scale, ranging from 1 (*never*) to 5 (*very often*). The DEBQ has high internal consistency (Cronbach's α ranging from .80-.95; Van Strien et al., 1986; Cronbach's α ranging from .90-.97 in the current sample).

Body Mass Index (BMI).

Participant's height and weight were measured by a nurse practitioner. BMI is calculated using weight (kilograms; kg) divided by height (metres squared; m^2), which was recorded on the patient information spreadsheet at the Centre for Healthy Active Living. Height and weight measurements were taken at the participant's baseline assessment, 6, 12, 18 and 24 month follow-up appointments to determine an accurate BMI for each time period.

Analysis plan

Data preparation

All continuous variables were screened for outliers using recommendations from Tabachnick and Fidell (2013) by examining semistudentized residual scores and leverage values. However, the final decision about whether to retain outliers was based on the contribution to the study and sensitivity analyses. Specifically, I examined bivariate correlations between variables with and without outliers to determine if the results were impacted by removing these participants. For all key variables, there were only one or two outliers present at each time point. Therefore, after completing sensitivity analyses these values were retained. Specifically, there were outliers for BMI across time points. However, these values were informative and important to the analyses since participants were sampled from the extreme end of the BMI distribution, outliers are expected and representative of the constructs of interest. Therefore, they were all retained for the remainder of the analyses. Additionally, all variables appear to have relatively normal distributions across time points. Therefore, there is support for a linear model to be used.

There were some concerns with multicollinearity in the variables of interest across time points. Specifically, body esteem subscales (i.e., appearance and weight esteem) were highly correlated ($r > .80$) at each time point and between time points. Therefore, only the appearance subscale was used for the main analyses. I decided to use appearance esteem instead of weight esteem since it is a more general body image factor that encompasses how individuals feel about their appearance, and it appears to be more related to BMI in males than weight esteem (Cragun et al., 2013). High correlations to this extent were unexpected between body esteem subscales. It is possible that the large

correlation between subscales is due to the nature of the sample. Since these youth have obesity, their weight and appearance beliefs are likely intertwined. For the remainder of this study, the term body esteem will be used, operationalized as individual scores on the appearance subscale of the BESAA.

External eating was not a key variable of interest for this project and meta-analytic results of Study 1 indicate that it is not a reliable source of information (e.g., it was inversely and not significantly related to BMI). Therefore, it was removed from further analyses.

Missing values. SPSS version 26 was used to examine the rates of missingness for all key variables. Any variable where missingness was less than 5% was not probed for missing data correlates as this is considered a negligible amount of missingness (Jakobsen et al., 2017). Baseline age and BMI, sex, total number of appointments, medical and mental health comorbidities, and all had less than 5% of missing values (see Table 28). However, all of the key model variables had between 9 and 98% missingness over the five time points (see Table 28). Since missingness was present at the scale level (not the item level), I did not examine correlates of item-based missingness.

Correlates of missingness. To begin, I examined patterns of missingness with t-tests and missing value analysis (MVA) to determine any potential missing data correlates. Due to the wide variety of missingness for each key variable at each time point, each variable was examined separately. Demographic variables and baseline BMI were examined as possible missing data correlates since none of the other variables had complete data. The results of the MVA indicated that total appointments attended and medical and mental health comorbidities would be appropriate missing data correlates for

most of the main variables. This is not surprising since the reasons for missingness in this data are largely known: appointment attendance (i.e., participants could not complete measures if they did not attend the appointment) and administrative errors and changes (measures were not administered; changes were made about when each construct would be measured).

These findings were confirmed by performing binary logistic regressions to predict missingness for each key variable at each time point from all other key variables. Participants who had complete data were coded as 0 (*complete*), whereas participants with missingness were coded as 1 (*not complete*). Total number of appointments and medical and mental health comorbidities were used to predict missing data. Results varied based on the outcome of interest. Medical and mental health comorbidities were related to missingness on some variables as participants with more comorbidities were more likely to have complete data. Additionally, participants who attended a higher number of total appointments had less missing data. These results indicate that there is evidence to support the missing at random assumption.

Multiple imputation. Due to the large amount of missingness on both predictor and outcome variables, multiple imputation was used to estimate the missing data. Multiple imputation is a Bayesian approach to dealing with missing data where multiple copies of the data are created and the missing values are generated using stochastic regression relations between observed data while incorporating model error (Enders, 2010; Jakobsen et al., 2017). Then the hypothesized model is fitted to each dataset and these results are pooled across datasets to give one set of results. These results are computed with pooled standard errors that account for the variability between datasets to

reflect any uncertainty associated with the missing values (Enders, 2010). Mplus version 8.2 was used to impute the data using a fully conditional specification imputation model.

A number of different iterations and thinning procedures were attempted by examining traceplots and potential scale reduction (PSR) values before the data converged. Total number of appointments, and medical and mental health comorbidities were used as auxiliary variables and values were imputed based on the information provided. Due to the complicated nature of the models and high degree of missingness, scale-level scores were imputed. It is important to reiterate that there was no item-level missingness on the scales but rather only scale-level missingness.

Data were imputed in long format (to maintain any clustered effects) and transformed into wide format once there was reliable data (i.e., stable traceplots and low PSR values) available. To impute the data, all key variables, missing data correlates, and demographic variables were included in the imputation process. A general rule is to impute 50 datasets (or more) to reduce sampling variability (Jakobsen et al., 2017; Sterne et al., 2009). Given the large amount of missingness in the current data, 100 datasets were imputed. When imputing data it is important to examine the traceplots to determine the number of iterations required for parameter convergence (Enders, 2010). Additionally, PSR values are necessary to indicate stable data (consistent values around one are an indication that the data has converged and that no additional benefit will be gained from more iterations).

One hundred datasets were imputed with 100,000 iterations, thinned at 5,000 iterations. To confirm that the data had converged, I also examined 200,000 iterations, thinned at 10,000. Traceplots and PSR values confirmed that the data appeared to be

stable around 100,000 iterations so the final imputed datasets were retained from the model with 200,000 iterations. To analyze the data, all 100 model results were pooled and examined simultaneously to produce one set of results.

Analyses

Latent Growth Curve Modelling (LGM) was conducted using Mplus version 8.2 to determine the growth trajectories for each key variable (i.e., body esteem, emotional eating, restrained eating, quality of life, and BMI). Robust maximum likelihood (MLR) estimation was used to provide standard errors that account for possible non-normality. For each of these variables, LGM was used to create two random variables (intercept and slope; see Figure 13 for an example) that represented average initial baseline scores (intercept), and average change over two years (slope). Each individual was allowed to vary from the mean intercept and slope values. Parameter estimates and variances for each latent variable are provided. The mean estimates (of the intercept and slope) indicate whether the values are different from zero, and the variances (of the intercept and slope) indicate if the values differ between people. If the intercept mean is significant, it indicates that the value is different from zero. The intercept mean represents the average baseline score of a variable across participants. If the intercept variance is significant, it indicates that there is variability in baseline scores for that particular construct between participants. The mean slope represents change or growth over two years in weight management (e.g., if this value is significantly different from zero). If the slope mean is significant, it indicates that there is significant change in the variable over time. If the slope variance is significant, it means that there are different rates of change between participants.

First, unconditional univariate models were run to determine the function of change over time for each key variable, independently. Linear and quadratic LGMs were tested and compared. To determine whether the models were a good fit for the data, fit indices and graphs were examined. Model fit was assessed with a number of fit indices including Akaike information criterion (AIC; a descriptive comparative indication of model fit using log likelihood values), Bayesian information criterion (BIC; descriptive fit index sensitive to sample size and the number of parameters being estimated), root-mean square error of approximation (RMSEA; measure of absolute fit and makes comparisons between the tested and saturated model, based on degrees of freedom; Kline, 2016), comparative fit index (CFI; adjusted based on sample size; compares a target model with a more restrictive baseline model; Kline, 2016), Tucker-Lewis Index (TLI; compares model fit of interest to a null model), and standardized root-mean square residual (SRMR; measure of the mean absolute correlation residual; square root of the difference between the residuals of the sample covariance matrix and the hypothesized model; used to estimate the likelihood of making Type I and Type II; Kline, 2016).

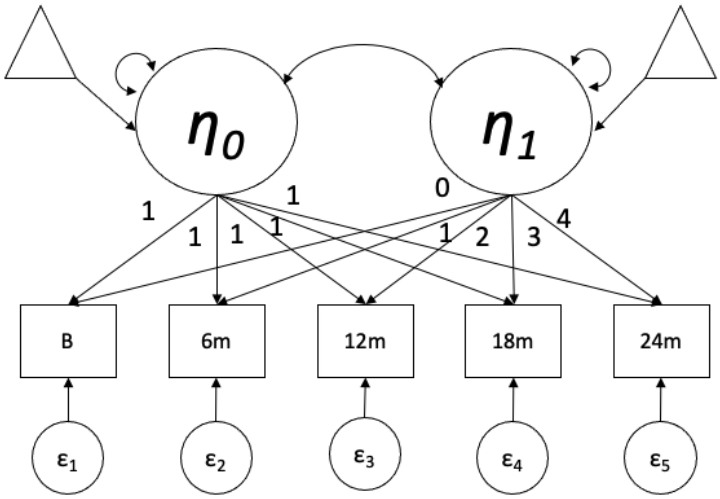
For the AIC and BIC, lower values suggest a better fitting model (Nylund et al., 2007; Singer and Willet, 2003). RMSEA and SRMR values below 0.05 indicate good fit, values between 0.05 and 0.08 suggest adequate fit, and values between 0.08 and 0.10 indicate mediocre fit (Kaplan, 2000; Kline, 2016). The CFI and TLI are more acceptable as values approach 1 and a model is considered to have good fit if the values are over 0.95 (Hu & Bentler, 1999).

Next, intercept and slope values of the variables (i.e., body esteem, emotional eating, restrained eating, quality of life, and BMI) were estimated simultaneously to

determine the associations between the latent variables. The rate of change (linear or quadratic) that was the best fit for each univariate model was added to the full bidirectional model. Regression paths were added between the latent variables to determine if initial scores of body esteem, emotional and restrained eating, BMI, and quality of life were related to change (i.e., slope values) in the other variables over two years (e.g., if the starting point of one variable is associated with change in another variable over time) to determine if there were any possible bidirectional effects (see Figures 14 & 15). To see how the variables change together, over time, correlations were estimated between slope values of each variable (see Figures 14 & 15).

Figure 13

Unconditional linear latent growth model



Note. B = baseline assessment; 6m = 6 month follow-up; 12m = 12 month follow=up; 18m = 18 month follow-up; 24m = 24 month follow-up; η_0=intercept; η_1=slope.

Table 28

Listwise Descriptive Statistics and Missingness and imputed estimates of Key Variables at each Time Point

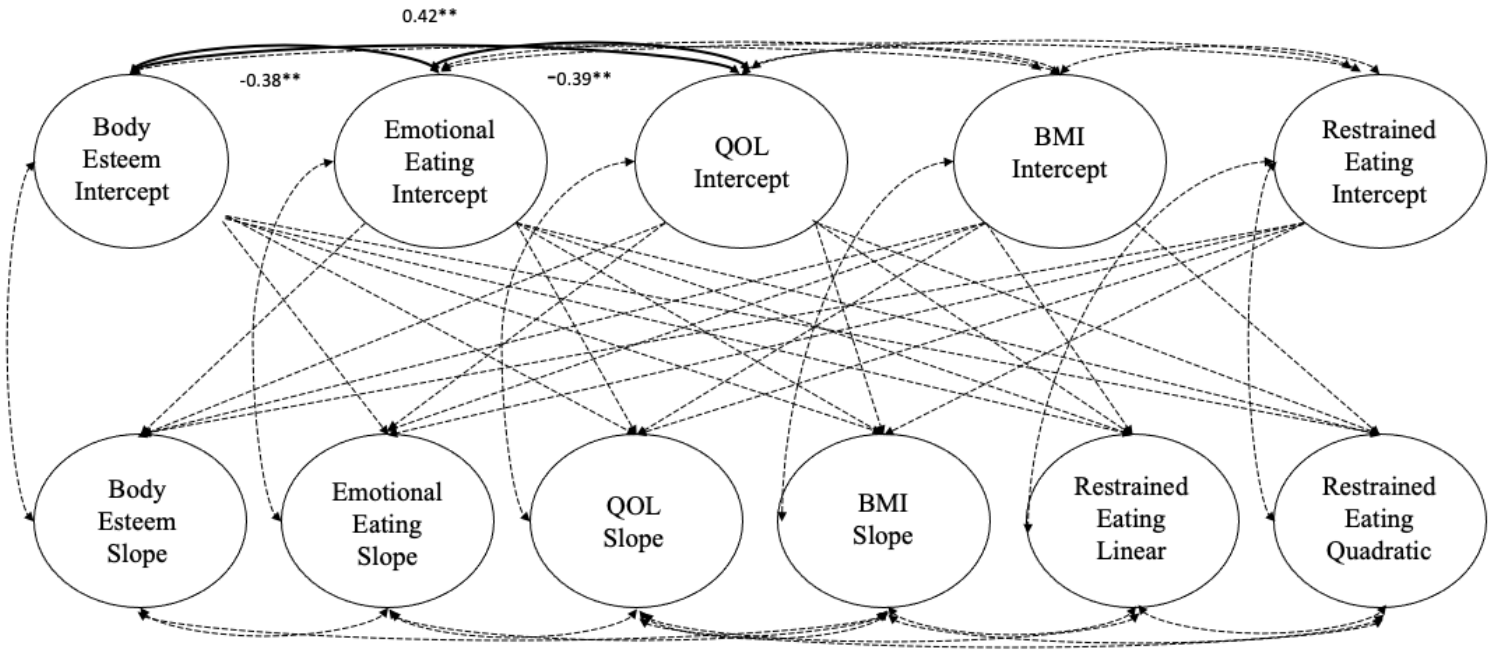
Variable	*N*	*M*	*SD*	Range	% miss	$M_{imputed}$	$SD_{imputed}$
Age T0	209	13.17	3.11	4-18	0.0	13.17	3.10
BMI T0	209	37.24	7.84	23-63	0.0	37.24	7.81
BMI T1	148	37.04	6.87	26-64	29.2	37.93	7.51
BMI T2	147	38.23	7.72	21-70	29.7	38.62	7.87
BMI T3	96	38.90	8.22	24-72	54.1	38.81	8.08
BMI T4	120	39.14	7.70	23-68	42.6	39.50	7.94
QOL T0	152	69.60	15.49	14-97	27.3	70.84	15.50
QOL T1	123	74.28	15.71	7-98	41.1	73.58	15.93
QOL T2	116	75.22	15.92	9-100	44.5	74.05	16.03
QOL T3	68	75.87	15.16	24-98	67.5	73.88	15.58
QOL T4	94	76.24	14.35	39-100	55.0	74.32	15.32
Restrained T0	104	2.45	0.73	1-4.5	50.2	2.32	0.75
Restrained T1	26	2.07	0.65	1-3.3	87.6	2.19	0.74
Restrained T2	75	1.94	0.67	1-3.8	64.1	2.13	0.74
Restrained T3	4	2.28	0.49	1.8-2.9	98.1	2.21	0.75
Restrained T4	63	2.12	0.83	1-4.8	69.9	2.19	0.77
Emotional T0	104	2.12	1.01	1-4.6	50.2	2.03	0.97
Emotional T1	26	2.07	1.02	1-4.2	87.6	2.00	0.95

Variable	*N*	*M*	*SD*	Range	% miss	$M_{imputed}$	$SD_{imputed}$
Emotional T2	75	1.94	0.92	1-4.8	64.1	2.00	0.95
Emotional T3	4	1.40	0.71	1-2.5	98.1	2.00	0.96
Emotional T4	63	1.87	0.85	1-5	69.9	1.99	0.94
Body Esteem T0	109	2.97	0.92	1-5	47.8	3.13	0.95
Body Esteem T1	29	3.33	0.99	1.3-5	86.1	3.23	0.95
Body Esteem T2	79	3.39	0.89	1.4-5	62.2	3.24	0.93
Body Esteem T3	4	3.40	1.33	1.5-4.6	98.1	3.21	0.95
Body Esteem T4	68	3.42	0.97	1.3-5	67.5	3.23	0.95
Total appt	206	13.01	11.77	1-63	1.4	13.02	11.74
MH_co	209	1.06	1.17	0-5	0.0	1.06	1.17
Med_co	209	1.83	1.15	0-6	0.0	1.83	1.15

Note. T0 = baseline; T1 =6-month; T2 = 12-month; T3=18-month; T4=24-month; QOL = Quality of life child report; Restrained = restrained eating; Emotional = Emotional eating; Total appt = total appointments attended over two years; MH_co = mental health comorbidities; Med_co = medical comorbidities; %miss = percentage of missing values; $M_{imputed}$ =imputed mean for 209 cases; $SD_{imputed}$ = imputed standard deviation for 209 cases.

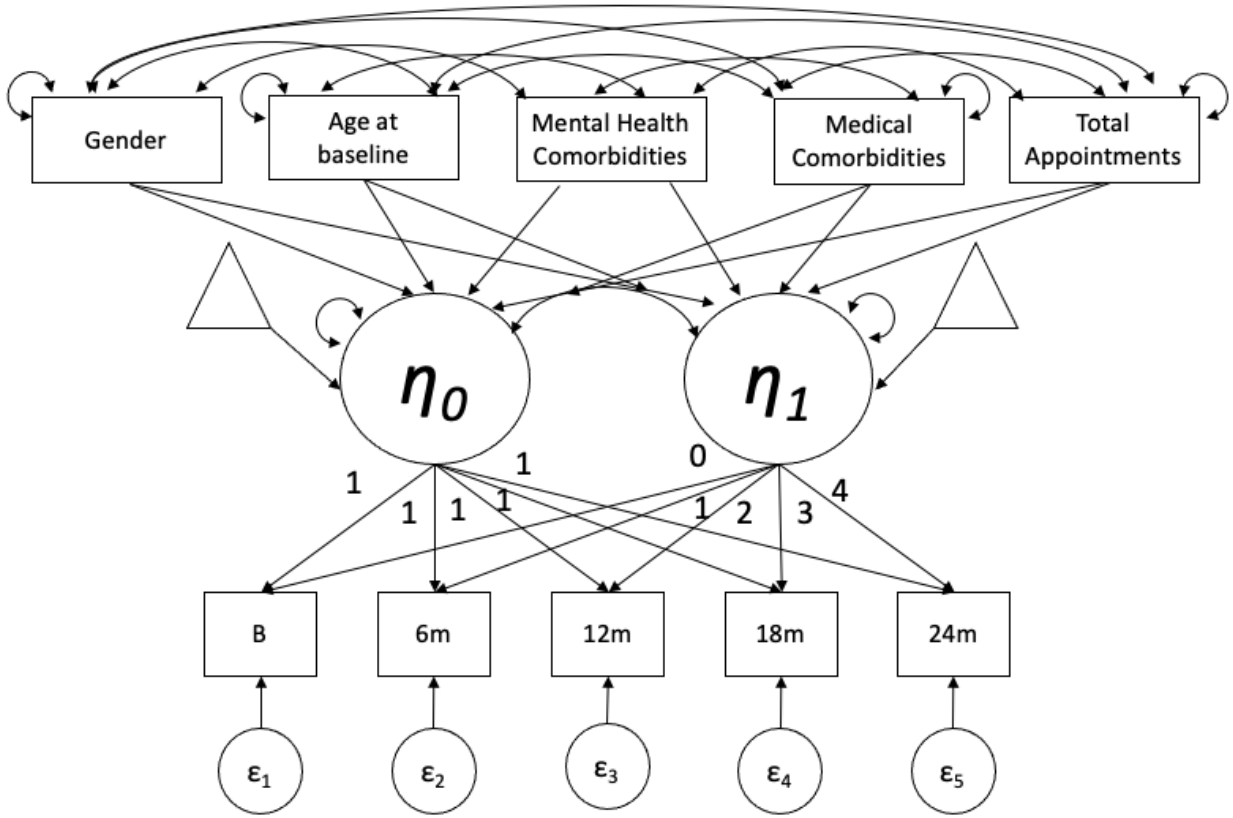
Figure 14

Bidirectional model of BMI, body esteem, disordered eating, and quality of life over two years in weight management



Note. This LGM examines the bidirectional effect of physical and mental health outcomes in youth with obesity over 24 months while controlling for sex, age at baseline, mental and medical health comorbidities. Each variable was measured at baseline, 6, 12, 18, and 24 months and intercept and slope factors were created. Dashed lines indicate nonsignificant pathways and bolded lines indicate significant paths $p < .01$. See Figure C for more detailed information about how each latent variable was created. The values included are the standardized results, which broadly represent the correlations between variables at baseline.

Figure 15
Example of the conditional Linear Latent Growth Model for each key variable in the bidirectional model



Note. B = baseline; 6m = 6 month follow-up; 12m = 12 month follow-up; 18m = 18 month follow-up; 24m = 24 month follow-up; η_0=intercept; η_1=slope; Each main variable (i.e., body esteem, emotional eating, restrained eating, BMI, and quality of life) has an intercept and linear slope factor, controlling for sex, age at baseline, mental health and medical comorbidities, and total appointments attended. Restrained eating has an additional latent variable that represents the quadratic slope.

Results

Associations between main variables

It was expected that body esteem, disordered eating, BMI, and quality of life would be associated within time points and pooled over time. The correlations between variables combined over time, are largely unchanged after multiple imputation (MI; see Table 29): 1) higher body esteem was significantly associated with lower restrained and emotional eating, and higher quality of life; 2) higher emotional eating was associated with higher restrained eating and lower quality of life; 3) higher restrained eating was associated with lower quality of life; 4) higher quality of life was associated with lower BMI scores. However, there were some discrepancies in the listwise and imputed correlations: 1) the association between age and emotional eating was not significant in the imputed data; 2) the association between BMI and emotional eating was not significant in the imputed data, and 3) the association between BMI and body esteem was not significant in the imputed data. These discrepancies are likely because the multiple imputation procedure incorporates some partialling of effects of variables and does not incorporate potential missing not at random relationships that cannot be accounted for in the MI procedure. Additionally, the *p*-values for the listwise correlations between BMI and body esteem and emotional eating were approximately $p = 0.04$. Therefore, it is not surprising that these correlations were no longer significant with the imputed data as it should produce less biased estimates than listwise deletion. Before testing the main hypotheses, it was important to examine how each variable changed over time.

Table 29

Correlations of continuous variables across time (listwise are below the diagonal/imputed are above)

	Age	BMI	QOL	Restrained	Emotional	Body Esteem
Age	-	0.40**	-0.03	0.00	0.07	-0.04
BMI	0.41**	-	-0.11*	0.02	0.07	-0.06
QOL	-0.06	-0.21**	-	-0.11*	-0.28**	0.29**
Restrained	-0.01	0.05	-0.29**	-	0.12*	-0.15**
Emotional	0.19**	0.13*	-0.61**	0.28**	-	-0.26**
Body Esteem	-0.11	-0.12*	0.62**	-0.43**	-0.56**	-

Note. QOL = Quality of life child/teen report; Restrained = Restrained eating; Emotional = Emotional eating.

* $p < .05$; ** $p < .01$.

Univariate models of change

The analytic sample included 209 participants, over five time points. Unconditional linear and quadratic models were fit to each variable. The model that produced the best fit and was supported by the literature was retained. Fit statistics for the best fitting univariate model for each variable are presented in Table 30. A linear univariate LGM for body esteem was determined to be the best fit (AIC = 2293.83, BIC = 2313.89, RMSEA = 0.02, CFI = 0.99, TLI = .99, SRMR = 0.06). The best fitting (linear) univariate model for body esteem is shown in Figure 16. Independent analyses of body esteem indicated that the intercept was 3.17, 95% CI [3.01, 3.32] which refers to the average body esteem score for participants at the beginning of treatment. This is a low to average score of body esteem compared to community samples that found average body esteem scores of 3.76 for males and 3.70 for females (Cragun et al., 2013). The slope for body esteem was not significant, indicating no significant change in body esteem over two years in weight management (see Figure 16).

Table 30

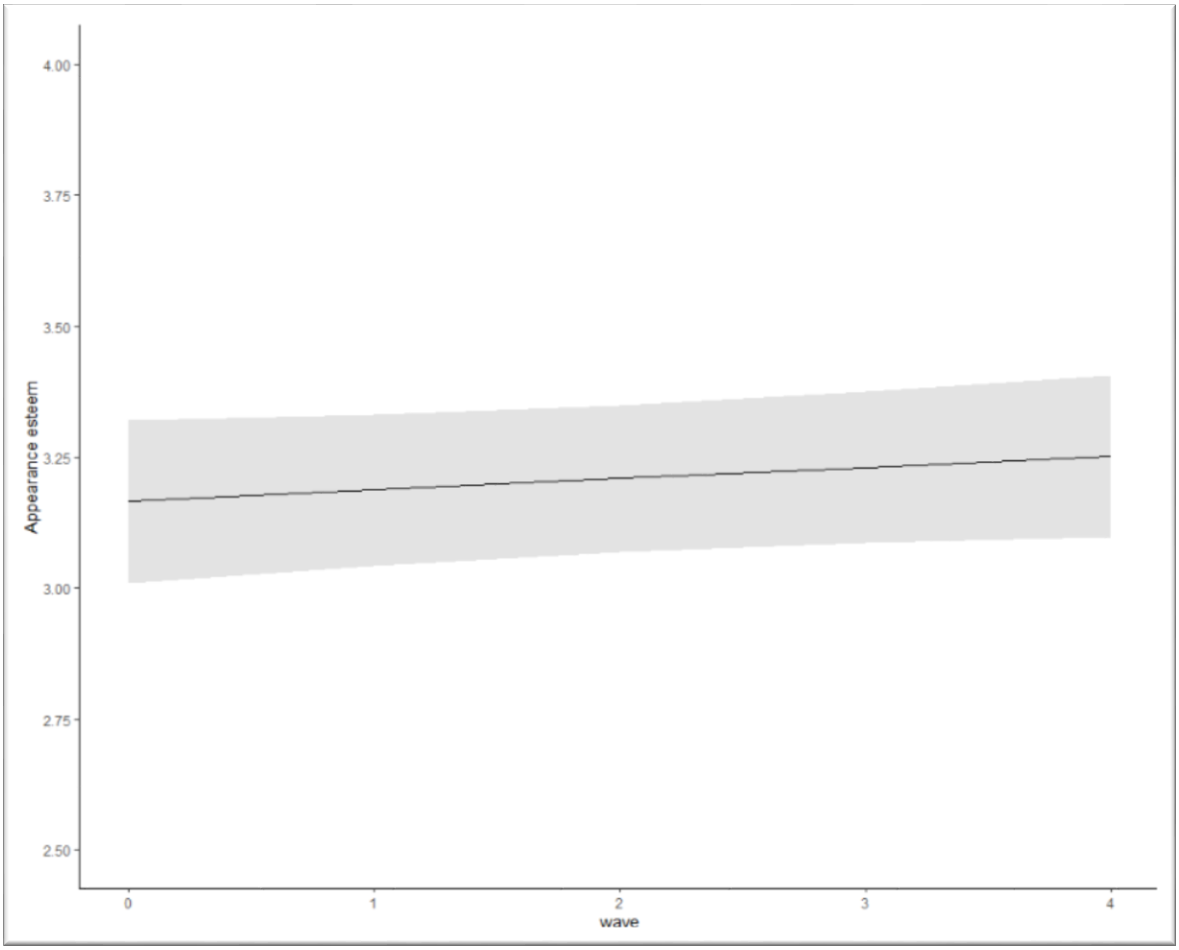
Fit statistics for univariate and bidirectional models

	Body Esteem Linear	Emotional Linear	Restrained Linear	Restrained Quadratic	QOL Linear	BMI Linear	Bidirectional Model
AIC	2293.83	2076.32	2124.86	2122.67	8166.41	5867.79	22069.15
BIC	2313.89	2096.37	2144.92	2156.10	8186.47	5901.22	22714.22
RMSEA	0.02	0.02	0.05	0.04	0.03	0.07	0.04
CFI	0.99	0.99	0.96	0.98	0.99	0.97	0.98
TFI	0.99	1.00	0.97	0.99	0.99	0.97	0.96
SRMR	0.06	0.04	0.07	0.06	0.07	0.07	0.05

Note. AIC = Akaike information criterion; BIC = Bayesian information criterion; RMSEA = root-mean square of approximation; CFI= comparative fit index; TLI = Tucker-Lewis index; SRMR = standardized root-mean square residual; Emotional = emotional eating; Restrained=restrained eating; QOL = quality of life; Bidirectional = final bidirectional model with all variables.

Figure 16

Linear Growth Trajectory of Body Esteem over two years in Treatment



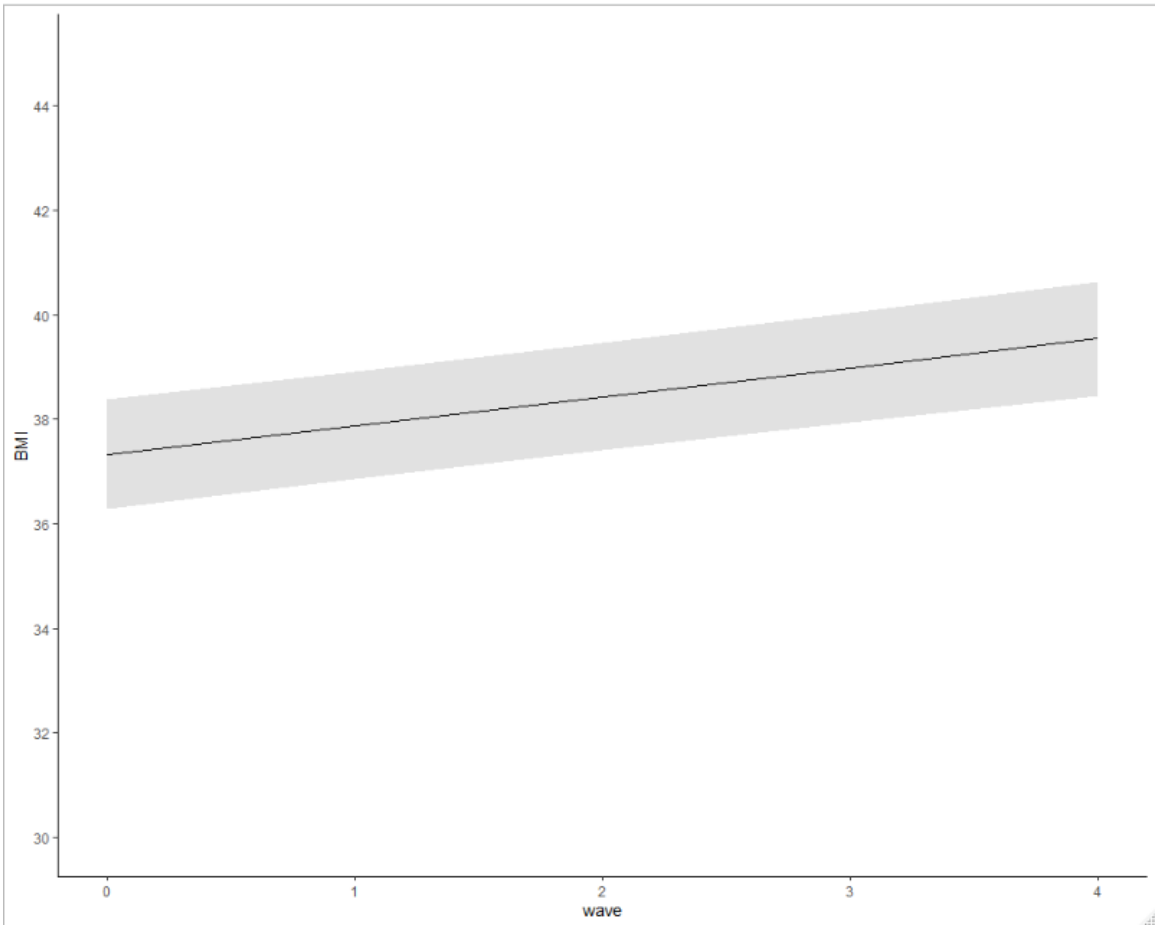
Note. Wave 0 =baseline; Wave 1= 6 months; Wave 2=12 months; Wave 3 =18 months; Wave 4 =24 months; Appearance esteem = body esteem; Body esteem ranges from 1-5.

A linear univariate LGM for BMI was determined to be the best fit (AIC = 5867.79, BIC = 5901.22, RMSEA = 0.07, CFI = 0.97, TLI = .97, SRMR = 0.07). The best fitting (linear) model for BMI is shown in Figure 17. The intercept of BMI was 37.33, 95% CI [36.27, 38.35] indicating the average BMI score at baseline. This is a high BMI score that is representative of having obesity according to the Centre for Disease Control (BMI > 30). Examining the mean slope values, BMI (0.552, $p < 0.001$) increased

in a linear fashion over time (Figure 17), indicating a small increase in BMI per follow-up. In the unconditional univariate model, the slope variance for BMI (0.371, $p = 0.535$) was not significant, suggesting that there was not significant between-person variability in the rate of change of BMI. However, in the LGM when all variables were analyzed simultaneously, the slope variance was significant, suggesting that there is some between-person variability in the rate of change of BMI over two years in treatment (see Table 31).

Figure 17

Linear Growth Trajectory of BMI over two years in Treatment

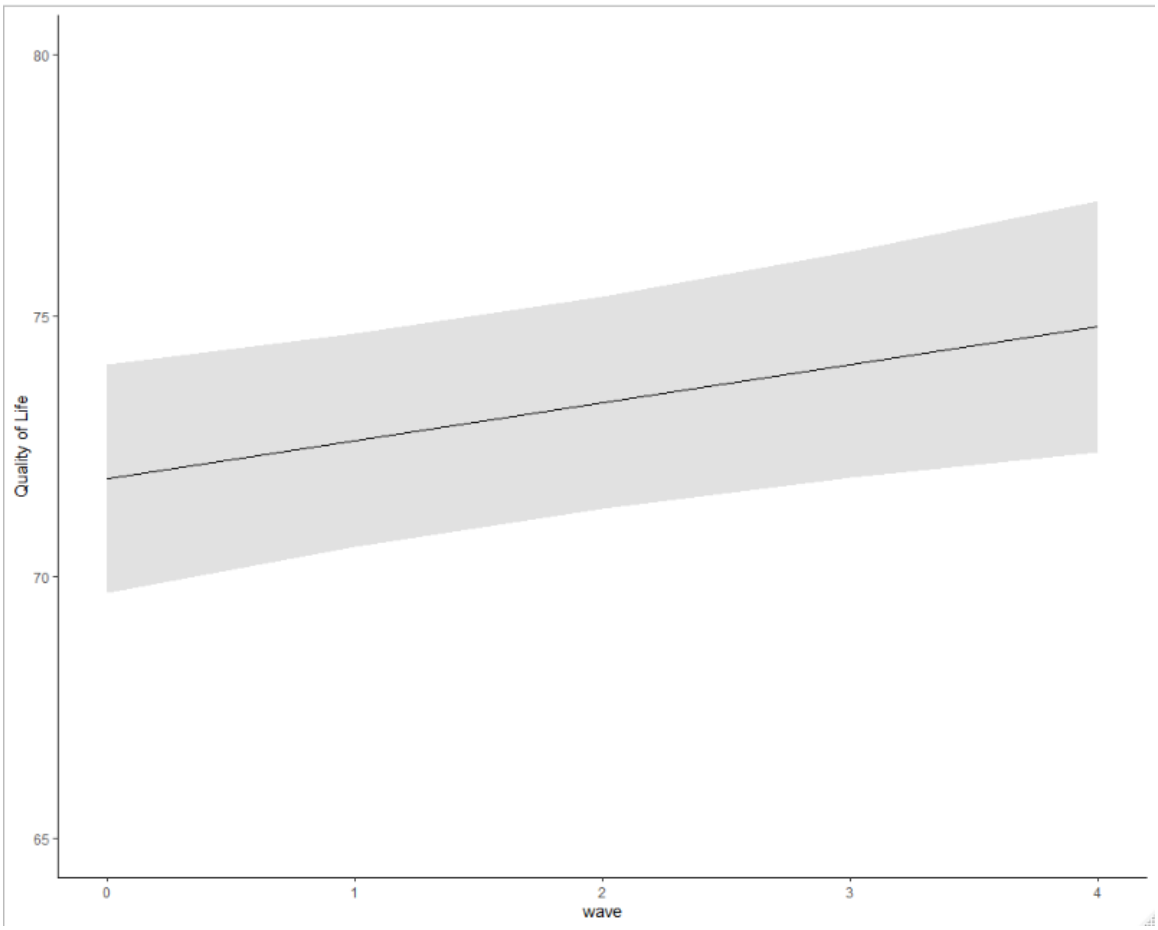


Note. Wave 0 =baseline; Wave 1= 6 months; Wave 2=12 months; Wave 3 =18 months; Wave 4 =24 months; BMI ranges from 21-72 across time points.

A linear univariate LGM for quality of life was determined to be the best fit (AIC = 8166.41, BIC = 8186.47, RMSEA = 0.03, CFI = 0.99, TLI = .99, SRMR = 0.07). The best fitting (linear) model for quality of life is shown in Figure 18. The intercept of quality of life was 71.89, 95% CI [69.71, 74.06] indicating the average quality of life score among participants at baseline. The observed mean is a low quality of life score compared to 'normative' samples of youth (e.g., mean score of a community sample is 81.08; Varni et al., 2006). The mean slope value for quality of life was significant (0.725, $p = 0.007$) and increased significantly (linearly) over time (see Figure 18). In the unconditional univariate model the slope variance for quality of life (1.175, $p = 0.432$) was not significant, suggesting that there was no significant between-person variability in the rate of change of quality of life.

Figure 18

Linear Growth Trajectory of Quality of Life over two years in Treatment



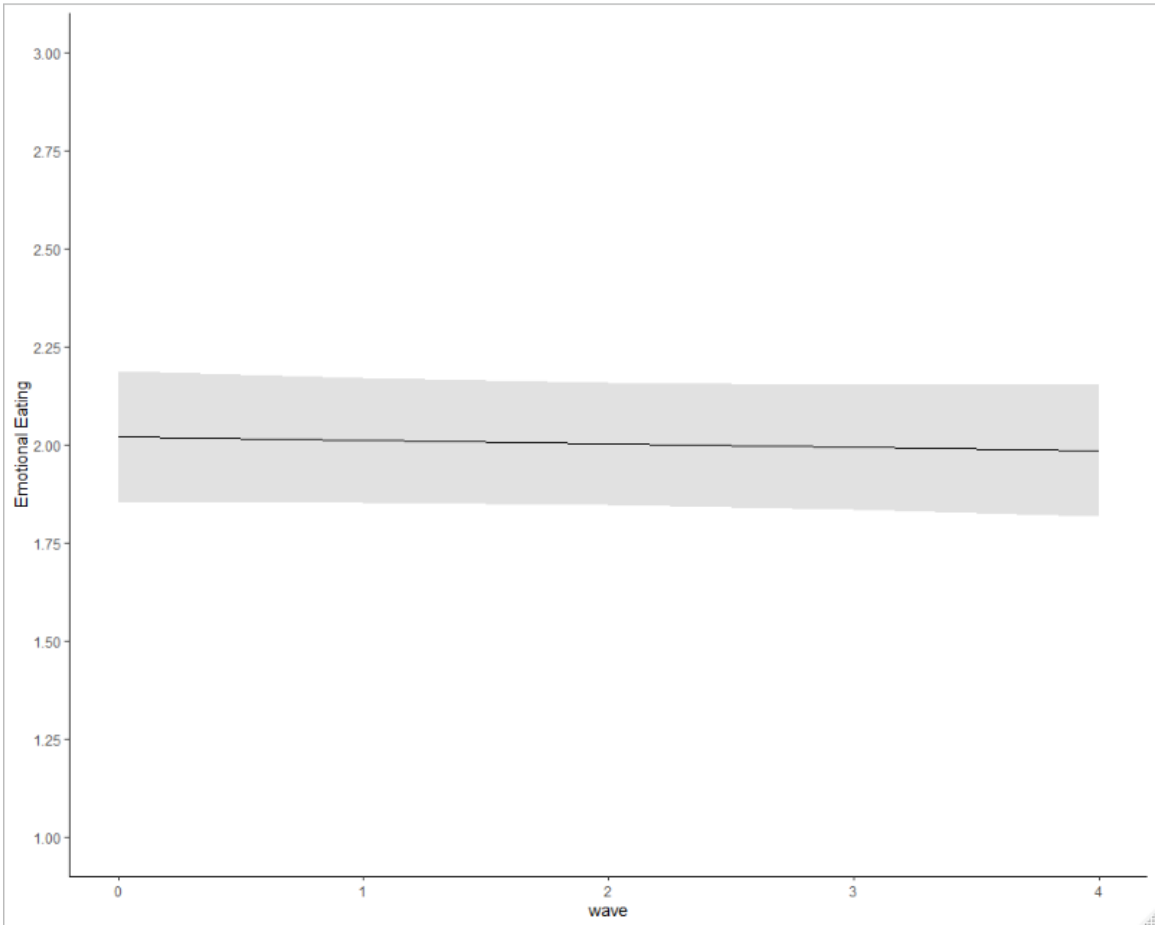
Note. Wave 0 =baseline; Wave 1= 6 months; Wave 2=12 months; Wave 3 =18 months; Wave 4 =24 months; Quality of life ranges from 7-100 across time points.

A linear univariate LGM was determined to be the best fit for emotional eating (AIC = 2076.32, BIC = 2096.37, RMSEA = 0.02, CFI = 0.99, TLI = 1.00, SRMR = 0.04). The best fitting (linear) univariate model for emotional eating is show in Figure 19. The intercept for emotional eating was 2.02, 95% CI [1.85, 2.19] which refers to the expected emotional eating scores at baseline. This score is slightly higher than scores for community samples of adolescents and adults across BMI categories (e.g., 1.84; Daly et

al., 2020; 1.89; Van Strien et al., 1986), and community youth with overweight and obesity (e.g., 1.93; Daly et al., 2020). The linear slope value was not significant, indicating no systematic change in emotional eating over two years (see Figure 19).

Figure 19

Linear Growth Trajectory of Emotional Eating over two years in Treatment



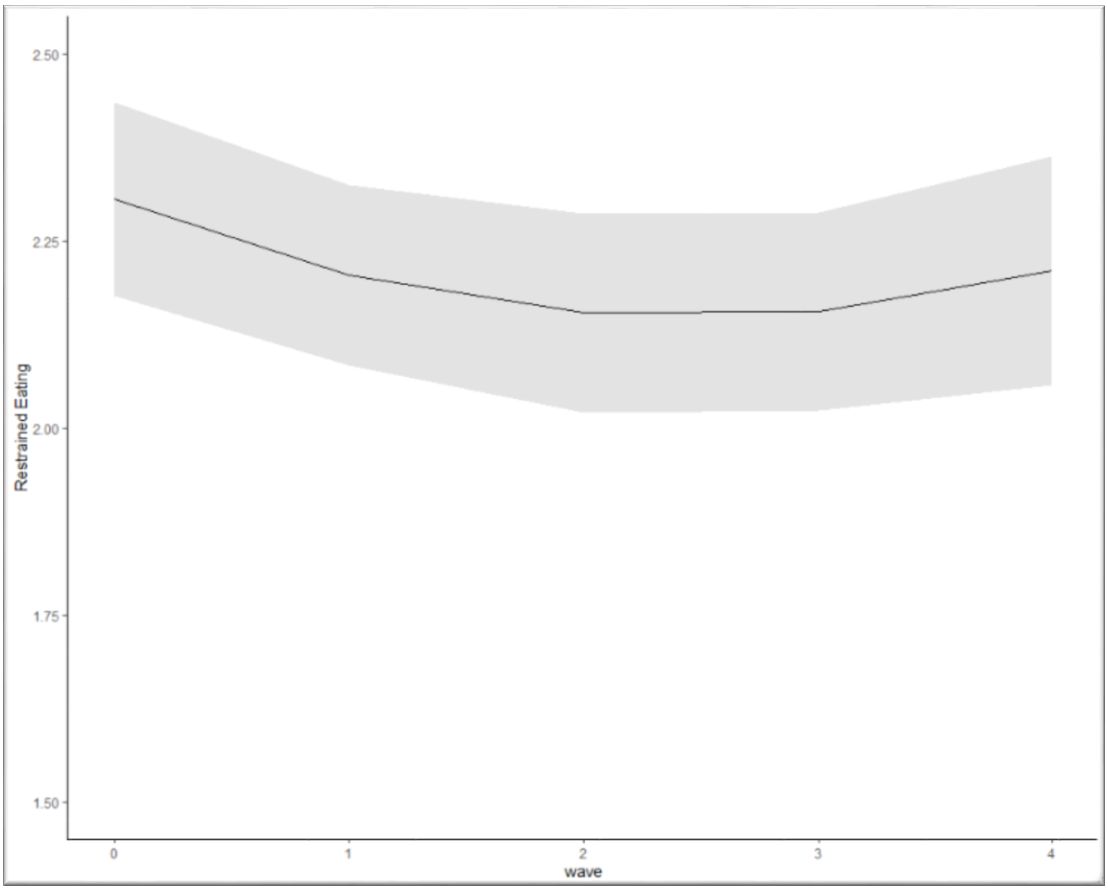
Note. Wave 0 =baseline; Wave 1= 6 months; Wave 2=12 months; Wave 3 =18 months; Wave 4 =24 months; Emotional eating ranges from 1-5.

A quadratic univariate LGM for restrained eating was determined to be the best fit (AIC = 2122.67, BIC = 2156.10, RMSEA = 0.04, CFI = 0.98, TLI = .99, SRMR = 0.06; Likelihood ratio test $p < .001$). The best fitting (quadratic) univariate model for restrained

eating is shown in Figure 20. The intercept for restrained eating was 2.25, 95% CI [2.13, 2.38] which indicates the expected restrained eating score at baseline. This is representative of a moderate score of restrained eating and is higher than average scores from community samples of adolescents (e.g., 1.79; Daly et al., 2020) and adults (e.g., 2.14; Van Strien et al., 1986) across BMI categories, and compared to community youth with overweight and obesity (e.g., 2.15; Daly et al., 2020). When estimating a quadratic function for restrained eating, there was a significant linear slope of -0.128, $p = 0.027$ suggesting that there was a slight decrease in restrained eating over time; however, the quadratic slope was not significant (0.026, $p = 0.060$). The quadratic model did indicate a significantly better fit to the data than the linear model for restrained eating (see Figures 20 and 21, respectively). Upon examination of the plots, it appears that restrained eating may decrease initially and then stabilize. Therefore, the quadratic slope was retained for restrained eating.

Figure 20

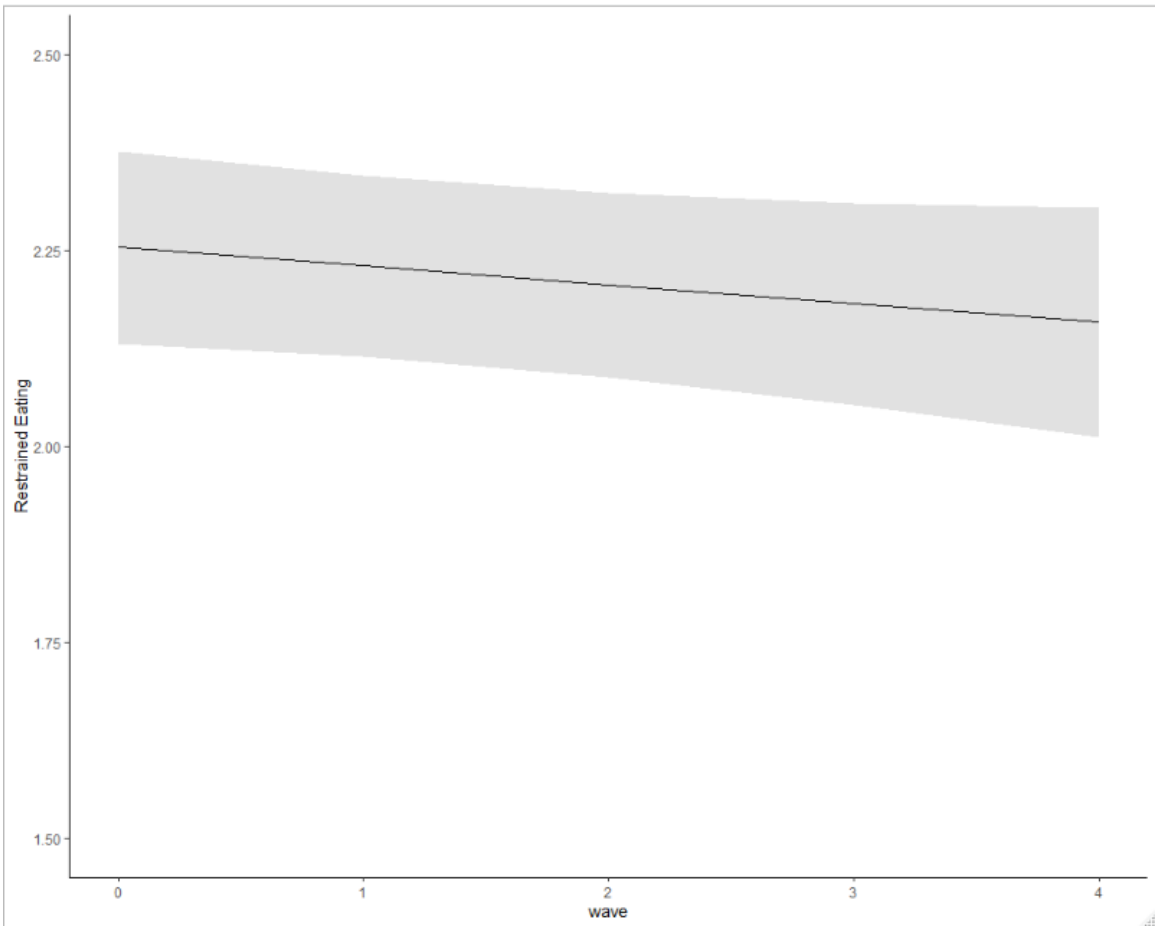
Quadratic Growth Trajectory of Restrained Eating over two years in Treatment



Note. Wave 0 = baseline; Wave 1= 6 months; Wave 2=12 months; Wave 3 =18 months; Wave 4 =24 months; Restrained eating ranges from 1-5.

Figure 21

Linear Growth Trajectory of Restrained Eating over two years in Treatment



Note. Wave 0 = baseline; Wave 1= 6 months; Wave 2=12 months; Wave 3 =18 months; Wave 4 =24 months; Restrained eating ranges from 1-5.

Table 31

Means, variances, and bivariate covariances of latent growth model unstandardized results without covariates below the diagonal. Values above the diagonal are the values from the complete bidirectional model, controlling for covariates.

Variable	*M*	S^2	Int BE	Int BMI	Int RE	Int Emo	Int QOL	Slope BE	Slope BMI	Slope RE	Quad RE	Slope Emo	Slope QOL
Int BE	3.17**	0.57**	---	-0.44	-0.07	-0.22*	3.63*	0.001	0.06	-0.01	-0.004	0.01	-0.30
Int BMI	37.34**	54.71**	-0.63	---	0.18	0.21	-6.25	0.001	0.18	0.001	0.00	0.00	-0.05
Int RE	2.16**	0.23*	-0.07	0.20	---	0.06	-0.83	-0.03	-0.08	0.004	0.004	0.01	-0.49
Int Emo	2.01**	0.68**	-0.24**	0.46	0.06	---	-3.73*	0.01	0.04	0.003	0.01	0.003	0.10
Int QOL	71.93**	159.14**	4.00**	-9.82	-0.84	-4.18**	---	0.00	0.001	0.00	0.001	0.001	0.29
Slope BE	0.02	0.002	-0.004	0.08	-0.01	0.01	-0.07	---	-0.01	0.00	0.00	-0.001	0.02
Slope BMI	0.55**	0.44*	0.04	-0.60	-0.02	-0.01	0.15	-0.01	---	0.01	0.001	0.01	-0.07
Slope RE	-0.02	0.00	-0.01	-0.01	0.01	0.003	-0.07	0.00	0.01	---	0.00	0.00	-0.02
Quad RE	0.02	0.00	-0.002	-0.01	0.001	0.004	0.08	0.00	0.001	0.00	---	-0.001	-0.01
Slope Emo	-0.01	0.001	0.01	-0.004	0.00	-0.005	0.19	-0.001	0.01	0.00	0.00	---	-0.03
Slope QOL	0.70*	1.12	-0.16	-1.66	-0.09	0.11	-2.34	0.03	-0.03	-0.02	-0.01	-0.03	---

Note. Int =intercept; Slope = linear slope; Quad =quadratic slope; BE = Body Esteem; RE = Restrained Eating; Emo = Emotional Eating; QOL = quality of life.

*$p < .05$. **$p < .001$.

Bidirectional relationships between initial status and change

Means, variances, and covariances from the LGM where all variables were analyzed simultaneously are presented in Table 31. The complete bidirectional model was analyzed to examine how these variables are changing together over time, and to test the main hypotheses of the present study (see Figure 14).

To test the first hypothesis, "those coming into the program with higher body esteem (i.e., body esteem at baseline) would have lower disordered eating (i.e., emotional and restrained eating) and higher quality of life at baseline, regardless of BMI" I examined the association between the intercept values of the variables of interest (in addition to BMI), while controlling for sex, age at baseline, total appointments attended, and mental and medical health comorbidities. Higher initial body esteem was independently associated with higher initial quality of life (*Cov* = 0.416, p = .001, 95% CI [0.182, 0.650]; see Figure 14), and lower initial emotional eating (*Cov* = -0.377, p = .001, 95% CI [-0.602, -0.152]). Higher initial body esteem was not associated with lower restrained eating ($p > .05$; see Table 31). Although it was not part of the main hypotheses, it is important to highlight that higher initial emotional eating was associated with lower initial quality of life (*Cov* = -0.394, p = .001, 95% CI [-0.615, -0.173]).

To test the second hypothesis, "patients with higher body esteem at baseline would have less disordered eating (i.e., emotional eating, restrained eating), and higher quality of life over time, regardless of BMI" I examined the slope values of disordered eating, BMI, and quality of life regressed on initial body esteem scores. Initial body esteem was not significantly associated with changes in quality of life, or disordered eating variables. Given the research suggesting that higher BMI is related to poor

physical and mental health, I also examined whether initial BMI was related to change in body esteem, disordered eating, and quality of life. Initial BMI was not associated with change in body esteem, quality of life or disordered eating variables. Additionally, none of the initial scores of any of the key variables (i.e., body esteem, restrained eating, emotional eating, quality of life, and BMI) predicted change in any other variable.

Finally, to test the third hypothesis, "positive changes in body esteem, would be associated with enhanced outcomes (i.e., improved quality of life and less disordered eating) over time," I examined associations between slope values of body esteem, quality of life and disordered eating while controlling for changes in BMI. Examining how variables 'move together' in time, there were no significant paths between slope values of any variables (see Table 31 for unstandardized results; see Appendix I for standardized results).

Few of the covariates were associated with the latent variables (see Table 32). Specifically, sex and age at baseline were associated with BMI at baseline (i.e., boys and older youth at baseline had higher initial BMI scores). Age at baseline was associated with change in BMI (see Table E), where younger youth had steeper increases in raw BMI than older youth over time. In other words, children's growth slows down as they age and after puberty which is consistent with BMI growth curves (de Onis et al., 2007; Nonnemaker et al., 2009). Finally, having more mental health comorbidities was associated with lower baseline quality of life scores.

In sum, quality of life and BMI were increasing, and restrained eating was decreasing and stabilizing over treatment. Higher body esteem, was associated with lower emotional eating, and higher quality of life at baseline. Trajectories of body esteem,

disordered eating, quality of life, and BMI did not appear to be significantly associated over two years in weight management.

Table 32

Growth curve model coefficients (unstandardized) for regression of intercepts and slopes of key variables on covariates at baseline and 95% confidence intervals for the complete bidirectional model

	Sex	Age at baseline	Total appointments	Medical comorbidities	Mental health comorbidities
	B [95%CI]	B [95%CI]	B [95%CI]	B [95%CI]	B [95%CI]
Int BE	0.10 [-0.18,0.39]	-0.02 [-0.08, 0.03]	-0.004 [-0.02, 0.01]	0.03 [-0.10, 0.17]	-0.06 [-0.20, 0.07]
Slope BE	0.02 [-0.05, 0.08]	0.003 [-0.01, 0.02]	0.001 [-0.002, 0.004]	-0.01 [-0.04, 0.02]	-0.002 [-0.04, 0.03]
Int BMI	2.10 [0.23, 3.96]*	1.07 [0.79, 1.36]*	-0.04 [-0.12, 0.03]	0.60 [-0.31, 1.51]	0.46 [-0.42, 1.34]
Slope BMI	-0.01 [-0.32, 0.31]	-0.08 [-0.13, -0.03]*	0.01 [-0.002, 0.03]	-0.003 [-0.15, 0.15]	0.04 [-0.12, 0.20]
Int RE	-0.04 [-0.27, 0.19]	-0.001 [-0.04, 0.04]	-0.003 [-0.01, 0.01]	0.02 [-0.08, 0.12]	0.01 [-0.09, 0.11]
Slope RE	-0.001 [-0.07, 0.07]	-0.01 [-0.02, 0.01]	-0.001 [-0.003, 0.002]	-0.002 [-0.03, 0.03]	0.001 [-0.03, 0.03]
Quad RE	-0.02 [-0.07, 0.04]	0.004 [-0.01, 0.02]	0.001 [-0.001, 0.003]	-0.01 [0.03, 0.02]	-0.002 [-0.03, 0.03]
Int Emo	-0.21 [-0.50, 0.09]	0.02 [-0.03, 0.08]	0.004 [-0.01, 0.02]	0.02 [-0.11, 0.15]	0.08 [-0.04, 0.21]
Slope Emo	-0.001 [-0.06, 0.06]	-0.001 [-0.01, 0.01]	0.00 [-0.002, 0.002]	0.002 [-0.02, 0.03]	0.005 [-0.02, 0.03]
Int QOL	0.95 [-3.43, 5.33]	0.02 [-0.76, 0.80]	-0.14 [-0.31, 0.03]	0.52 [-1.33, 2.36]	-3.46 [-5.35, -1.57]*
Slope QOL	0.43 [-0.67, 1.53]	0.01 [-0.20, 0.23]	0.01 [-0.04, 0.05]	-0.11 [-0.59, 0.37]	0.26 [-0.22, 0.73]

Note. Int =intercept; Slope = linear slope; Quad =quadratic slope; BE = Body Esteem; RE = Restrained Eating; Emo = Emotional Eating; QOL = quality of life.

* $p < .05$.

Discussion

Pediatric obesity is a complex chronic condition. Youth with obesity often experience more weight stigma and bullying (Van Geel et al., 2014), high rates of anxiety and depression (BeLue et al., 2009; Phillips et al., 2012), low body image (Wardle & Cooke, 2005), and poor quality of life (Schwimmer et al., 2003; Wharton et al., 2020). Tertiary care programs aim to target a wide range of physical and mental health behaviours that could improve the quality of life for youth with obesity (e.g., diet, sedentary behaviour, mental health, family and peer relationships). The present study examined the impact of a tertiary care program on physical and mental health of youth with obesity over two years.

Despite the number of treatment programs and options available, rates of childhood obesity remain relatively stable (Hales et al., 2017), and outcomes from treatment programs are often modest and variable (Altman & Wilfley, 2015). One study of a family-based program found that the treatment program was only significantly beneficial for youth with mild-to-moderate obesity, not for those with severe obesity (Barlow et al., 2020). Additionally, health professionals have identified a number of barriers that are related to treatment adherence and success, including logistical priorities, complex lives, parental role modelling, and family tension (Silver et al., 2019), and some research suggests that it might be more beneficial to integrate obesity treatment into existing service structures (e.g., after-school programing; Hennessy et al., 2019).

Program evaluation of current obesity treatments has varied and often includes high levels of missing information, as program attendance, and completion of assessment measures continue to be a problem in evaluating obesity-related treatment and weight

management. One review found that family-based treatment was advantageous for overall quality of life outcomes but that more research needed to be conducted to advise on the 'best' course of treatment for childhood obesity (Altman & Wilfley, 2015). Thus, it is important that current research considers program adherence and use of appropriate statistical techniques to account for missing data to evaluate treatment outcomes.

The focus of the present study was to evaluate the role of body esteem over two years in a multidisciplinary weight management program designed to improve the overall quality of life of children and youth and their families with complex obesity while encouraging healthy lifestyle behaviours that are attainable and realistic for the family unit. This program takes a patient-specific approach to ensure that each child is receiving care that is tailored to their needs. The Centre for Healthy Active Living (CHAL) uses Health at Every Size (HAES) messaging to inform patients that healthy bodies come in all shapes and sizes, and improving overall health does not necessarily translate to weight loss. As will be described below, much like the literature described above, the evaluation of the current program was challenging, given the high degree of missing data and common themes that are present in the first two years of a new clinical program (e.g., administrative errors and changes in collection of program evaluation measures).

While body esteem was stable over time and had no significant association with change in program outcomes over time, this does not indicate that this weight management program was unsuccessful. Generally, the results suggested that quality of life increased and restrained eating decreased over time, both of which are positive changes for children in this program. Raw BMI increased slightly over time, however, it appears to be indicative of 'normal' developmental growth, rather than a failing of the

program (Cole, 2000), and is consistent with samples of youth with overweight and obesity (Carter et al., 2012; Hebert et al., 2020). Additionally, this weight management program does not consider BMI reduction as a measure of success but rather improvements in overall mental and physical health are goals of the current program.

There were three hypotheses in the present study:

1. Patients coming into the program with higher body esteem would have less disordered eating, and higher quality of life at baseline.
2. Higher initial body esteem scores would be associated with decreased disordered eating and increased quality of life over time.
3. Positive changes in body esteem would be related to enhanced outcomes (i.e., improved quality of life and less disordered eating) over time.

The first hypothesis was partially supported. Higher initial body esteem was associated with lower emotional eating and higher quality of life at baseline. These associations suggest that there is a link between body esteem, eating behaviours, and quality of life in youth with severe complex obesity.

A cross-sectional study of youth across pediatric weight management programs in Canada found that youth with “mixed -severe” disordered eating (which included high levels of emotional eating) had significantly worse body esteem than youth with more moderate levels of disordered eating (Clairman et al., 2019). This finding suggests that the connection between body esteem, and emotional eating appears to be important to consider within a subgroup of youth with obesity (Clairman et al., 2019). A possible explanation for this association is the intersection of body image and emotional regulation.

Research suggests that youth eat in response to mood states (Shapiro et al., 2007). One longitudinal study of youth found that poor emotional regulation predicted emotional eating in adolescents across BMI categories (Shriver et al., 2021). However, researchers speculated that body image may be important for the ability to regulate emotions, as the association between emotional regulation and emotional eating was highest among youth with poor body image (Shriver et al., 2021). Additionally, having a negative body image at age 15 was associated with more emotional eating at age 17 in youth with overweight and obesity but not for those with an average BMI (Shriver et al., 2021). Thus, it was speculated that fostering positive body image could be protective against emotional eating in youth with obesity (Shriver et al., 2021).

The association between body image and emotional eating was confirmed in the present study. Therefore, promoting a positive body image in childhood may be protective against emotional eating behaviours in youth, especially for those with obesity as negative body image appears to be more harmful for youth with higher BMIs.

The positive association between body esteem and quality of life is consistent with previous research with children and adults (Haraldstad et al., 2011; Liu et al., 2019; Nayir et al., 2016; Yilmaz & Yillmaz, 2019). Although body esteem was only associated with quality of life at baseline (not over time), research suggests that body image might be more impactful on overall wellness than BMI (Kilpela et al., 2019; Kolodziejczyk et al., 2015). A study of adolescents with overweight and obesity found that body image mediated the association between BMI and health-related quality of life (Kolodziejczyk et al., 2015).

Another study of older women found that body image mediated the association between BMI and wellness, sleep, psychosocial impairment, and consumption of nutrient dense foods (Kilpela et al., 2019). Coupling the results from the current study with recent research, it appears that body image may be protective against the negative consequences that BMI can have on overall well-being, making body image a promising avenue for weight management intervention.

Unexpectedly, body esteem was not associated with restrained eating at baseline. This finding could be attributed to a lack of patient knowledge about proper eating behaviours pre-treatment. A common societal misconception about weight loss is the necessity of restricting calories. Therefore, families may not have been aware of the negative consequences of restrained eating and thus youth were engaging in restrained eating in an attempt to be more 'healthy' or to decrease their weight, even youth with more positive body image. This could be one explanation for the higher than average restrained eating scores that were present at baseline in the current study.

Additionally, Clairman and colleagues (2019), found that restrained eating did not differ across different eating phenotypes in youth with obesity. It is possible that restrained eating is common among all youth with higher average weight and obesity due to the misconception about needing to restrict calories to improve their overall well-being. Therefore, the high presence of restrained eating across all youth with obesity might explain the lack of correlation between restrained eating and other variables in the present study.

The second hypothesis was not supported in that higher initial body esteem was not related to favorable changes in program outcomes over time. The only variables that

changed over time were BMI, quality of life, and restrained eating. From the results it appears that the increase in BMI is likely due to typical developmental changes as younger children had more accelerated growth over two years, and boys and older youth had higher initial BMI scores (Carter et al., 2012; Cole, 2000; Hebert et al., 2020). BMI was not expected to be associated with body esteem over time, therefore, it is not surprising that initial body esteem was not significantly related to BMI over time.

The slight decrease in restrained eating might be explained by program education, and/or reductions in family conflict. Throughout the CHAL program, there was time spent discussing how restricting food negatively impacts your hunger cues and hormones, through regular one-on-one meetings with health care professionals about the harms of dieting, taking a non-restrictive stance with food, hunger management, managing hunger cues, and finding 'balance;' and there were group sessions that families attended that provided general information about weight science and eating behaviours. Therefore, the program 'treatment effect' alone may be the reason for the decrease in restrained eating.

It is also possible that the decrease in restrained eating could be explained by a decrease in family conflict. Research suggests that higher levels of parent-adolescent conflict predicts restrained eating (Darling et al., 2019). After partaking in the family-based nature of the weight management program, there may be improvements in family cohesion and thus, a decrease in restrained eating.

The increase in quality of life over time could be attributed to improved mental health in youth, and increased family cohesion. The number of mental health comorbidities that youth had at baseline were associated with initial quality of life in this

sample. It is possible that the psychological counselling that youth attended as part of the CHAL programing had a significant impact on mental health, and thus, improved quality of life.

Research on children and adolescents has found an association between mental health and quality of life (Stevanovic, 2013). A study that included the current sample of youth found modest improvements in mental health and quality of life over two years in treatment (Buchholz et al., 2020). While this study did not examine how these variables 'move together' in time, it is possible that the increases in mental health and increases in quality of life are happening simultaneously. In adults with obesity who had undergone gastric bypass surgery, improvements in depressive symptoms after surgery were a better indicator of improved quality of life at one-year follow-up compared to BMI change (Wimmelmann et al., 2014). Therefore, mental health might be a key contributor to improved overall quality of life in these youth.

The family-based nature of this program may improve family cohesiveness and overall well-being. Pediatric obesity is more common in families with higher stress and increased poverty and thus lower family cohesion and poorer family functioning (Zeller et al., 2007; De Sousa, 2009). A systematic review of family functioning and overweight and obesity found that childhood overweight and obesity was associated with poor family functioning across studies (Halliday et al., 2013). A recent study found significant improvements in the quality of life of youth at the end of an intensive family-based lifestyle treatment program, and at one-year post-treatment, despite weight regain post-treatment (Hoedjes et al., 2018), indicating that family-based treatment may be ideal for increases in quality of life through improvements in family functioning.

One study found a link between family cohesion, body esteem, and social life which in turn was related to lower internalizing symptoms in youth with obesity (Frontini et al., 2018). It is possible that improvements in family cohesion and social life may be associated with improved mental health, which could be influencing overall quality of life. Therefore, quality of life may have increased due to improved family cohesion and mental health. Future research should examine the longitudinal bidirectional association between family cohesion, mental health, and quality of life among youth in weight management.

Finally, the third hypothesis was not supported. Changes in body esteem were not associated with changes in other outcome variables. In fact, body esteem was remarkably stable over time. There are several explanations for why body esteem did not change over time. First, it might be a relatively stable construct. Community samples of youth have found conflicting evidence for change in body esteem over time. Some researchers have found no change in body esteem over time in youth (Zimmer-Gembeck et al., 2018), particularly after mid-adolescence (e.g., age 14; Wang et al., 2019). Others have found a linear decrease in body esteem throughout adolescence (Gagne, 2020; Lamb et al., 2021); and some have found a cubic trajectory to be the best fit for body esteem over development (Nelson, 2018; Frisen 2015). Lacroix and colleagues (2020) found different trajectories (over a four-year span) based on initial level of body esteem (M_{age} at baseline = 11.14). A slightly increasing linear trajectory was the best fit for youth with high initial body esteem, a cubic trajectory was more appropriate for youth with moderate initial body esteem (decreased between ages 7 and 10, increased slightly at age 11), and there

was no change in body esteem over time for youth with low initial body esteem (i.e., there was constant low body esteem across time).

It is possible that stability of body esteem as opposed to a decrease in body esteem over time, might be a relatively good thing during adolescence when we expect to see a decrease in body esteem. For example, a recent longitudinal study of community youth found that appearance and weight esteem significantly decreased over time during the adolescent period (Lamb et al., 2021). Perhaps stability in body esteem over time is a sign of treatment success.

While some studies of youth with obesity in treatment have found positive changes in body image over time (Herget et al., 2015), others have found no change for youth in conventional (non-surgery) treatment (Legenbauer et al., 2020). Overall, it appears that body image may play a protective role in outcomes for youth with obesity, but *body esteem* may be a particularly challenging self-perception to change. A recent meta-analysis of pediatric lifestyle treatment for obesity found small to moderate improvements in body image over the first two years of treatment, except for studies that operationalized body image as body esteem (Gow et al., 2019).

Thus, a second explanation for the stability of body image in the present study may be the way it was operationalized. Gow and colleagues (2019) found that of the 40 pre/post-intervention studies that included body image outcomes for meta-analysis, a significant increase in body image was found for studies that measured body satisfaction/dissatisfaction (e.g., *I think my stomach is too big*; Gardner et al., 1983), physical appearance satisfaction (e.g., *Are satisfied with their face and hair*; Muris et al.,2003), weight concern, and shape concern (e.g., *How uncomfortable have you felt*

seeing your body (for example, seeing your shape in the mirror, in a shop window, reflection, while undressing or taking a bath or shower)?; Fairburn & Beglin, 1994), but not for body esteem (e.g., *I like what I look like in pictures;* Mendelson et al., 2001; Gow et al., 2019). Therefore, body esteem may not be prone to change over time due to the nature of the Likert items (i.e., the items might be too vague which elicit a more neutral response). It is possible that the broad nature of the BESAA items results in consistent answers over time, regardless of changes in specific areas of body satisfaction. Future research should include multiple measures of body image to determine if there are differing trajectories over time based on the construct and measure used.

A secondary goal of this study was to examine the bidirectional nature of these variables (body esteem, BMI, disordered eating, quality of life) over time. It is important to note that none of the initial values of these variables influenced trajectories of any other variable over time. While this was not a specific hypothesis, it is novel that initial BMI was not related to program success or initial disordered eating, quality of life, or body esteem. It is known that youth with higher BMIs report more disordered eating, lower quality of life, and lower body image compared to youth with average weight (Gibson et al., 2017; Janicke et al., 2007). However, for youth with obesity, with BMI scores already at the extreme end of the distribution, BMI itself may be less predictive of psychosocial outcomes. A study of children and youth enrolled in pediatric weight management programs found that mental health and metabolic issues were prevalent among all youth with obesity irrespective of BMI status (e.g., class I, II, or III; Hadjiyannakis et al., 2019). Therefore, these findings suggest that the simple fact of

having obesity places youth at a greater risk for metabolic and mental health comorbidities, regardless of severity.

Another explanation could be that these youth are not destined to poor psychosocial health outcomes because of their obesity, but rather, there are other factors outside of their weight that are instrumental in their health status that were not measured in the current study, such as weight-based teasing. Weight-based teasing has been linked to negative psychosocial and physical health outcomes in youth (Janicke et al., 2007) such as higher engagement in disordered eating behaviours (Neumark-Sztainer, Falkner, et al., 2002), binge eating (Haines & Neumark-Sztainer, 2006), depression (Adams & Bukowski, 2008), and physical inactivity (Storch et al., 2007). Therefore, weight-based teasing may be an important indicator of success and change in psychosocial health during weight management programs, above and beyond BMI status.

Limitations

There were several limitations to the present study, most notable are that (a) the main analyses had a low sample size, (b) there was a large amount of missingness, (c) two-years may not be long enough to demonstrate change in mental health variables (e.g., body esteem), (d) the body esteem measure that was used may not be prone to change and, (e) the sample may not have been as cohesive as previously assumed.

The sample used for this study was from an archival dataset that ranged over the first two years of a weight management program. Typically, for a univariate model (of a single growth trajectory), it is recommended that there are 20 observations for each parameter estimated in order to ensure model identification (Jackson, 2003; Kline, 2015). This means that if a univariate linear model is estimating two means (intercept and

slope), two variances (intercept and slope), the covariance between the intercept and slope, and the residual variances of the construct at each time point (e.g., 5 residual variances, one for each time point), 10 parameters would be estimated, and thus, 200 participants would be needed to ensure model identification. However, if the residual variances are fixed to be equal, only 5 parameters would be estimated which means 100 participants would be sufficient. While there were enough participants to estimate the univariate models in the present study, the entire bidirectional model was unlikely to produce robust parameter estimates.

Another statistical complexity of the present study was the high degree of missing information. While multiple imputation (MI) is the most conservative method of accounting for missing data, having the actual information is always ideal. Research demonstrates that using MI is the 'best' option for dealing with missing data as it produces less biased estimates and more accurate inferences compared to listwise deletion and other missing data techniques (e.g., mean-imputation; Jakobsen et al., 2017). Additionally, MI allows for the incorporation of auxiliary variables that are predictors of missingness that add information to the imputed estimates. Being able to impute the data allows for progress in this area of research; if researchers were insistent on only analyzing complete or nearly complete data, it would be difficult to ever advance clinical research.

Two years may not be long enough to see change in body esteem, and body esteem might be a stable construct, especially after adolescence. As previously mentioned, body esteem may not be sensitive to change over time, especially after puberty. Since the mean age of this sample was 13 and youth with obesity tend to receive

negative body messages earlier than youth with average weight (Frisen et al., 2008; Neumark-Sztainer, Falkner, et al., 2002; Puhl & Latner, 2007), it is possible that their body esteem identity is formed at a young age and that the high degree of weight stigma messages that youth with obesity receive may reduce the likelihood of body esteem improving over time.

A recent 14-year longitudinal study found that children who were victimized more at age 10 had higher body dissatisfaction at age 10, and their negative body image was maintained throughout adolescence into adulthood (Gattario et al., 2020). Further, childhood bullying predicted negative body image in adolescence which predicted disordered eating in adulthood (Gattario et al., 2020). Studies that did find change in general body image over time did so with the exception of body esteem (Gow et al., 2019). Another possible reason for body esteem stability in the present study is the choice of measure used.

The present study used the Body Esteem Scale for Adolescents and Adults to measure body esteem. This measure has been validated with adolescents (Mendelson et al., 2001), and variations of this scale have been validated with children (Mendelson & White, 1982) and adults (Franzoi, 1994; Franzoi & Herzog, 1986). However, these body esteem measures and possibly body esteem as a construct, are more appropriate for cross-sectional research than longitudinal studies. The nature of the BESAA Likert items are vague and this may yield more consistent answers over time, suggesting that body esteem as measured this way, is a relatively stable construct. Researchers who have used the BESAA to measure body image throughout pediatric obesity treatment have found that while other measures of body image change over treatment, body esteem does not (Gow

et al., 2019). It is possible that low body esteem perceptions are especially difficult to change in youth in weight management. Therefore, body esteem and particularly the BESAA may not be ideal constructs to examine longitudinally as they may not be sensitive to changes of body perception.

The current treatment program did not directly target body image in their intervention but rather promoted a body-positive, Health at Every Size (HAES) framework. It is possible that there was no change in body esteem due to the lack of consistent intervention aimed at directly improving body esteem. It may be advantageous if CHAL implemented a short-term body image intervention during treatment to see if this has an impact on body esteem in both short and long-term follow-ups. If successful, incorporating more consistent body image programing into weight management programs could be another way that clinicians and researchers can improve the quality of life of youth with obesity.

Finally, it is possible that examining children and adolescents over one treatment trajectory did not allow for nuances related to development to emerge from the results. Once more data are collected, it would be best to see if there are different trajectories of body esteem, disordered eating, and quality of life for youth who entered the program during childhood compared to those who entered the program during adolescence. The results of the present study do not suggest that there are different trajectories for these variables based on age but with more participants there should be further inspection of the data to confirm these results.

Strengths

There were many strengths of the present study. First, this was an examination of a clinical sample of youth with obesity. While there are a number of multidisciplinary weight management programs throughout urban areas of Canada, very few programs have published treatment outcomes. Furthermore, few studies have examined the long-term results of a multidisciplinary program that does not focus on a reduction in BMI as a main outcome.

Second, this is one of the first studies examining bidirectional associations of BMI, body esteem, disordered eating, and quality of life in obesity management, and these results are novel with regard to the examination of variables that are uncommon outcomes in childhood obesity research (e.g., body esteem). Future research should extend these findings by studying if these variables are most impacted pre-puberty for children with obesity. Also, it would be beneficial to examine these trajectories in a community sample to see if there are similar associations or if the findings of this study are specific to youth with obesity who are attending weight management.

Finally, this study used superior missing data techniques and examined a complex statistical model of growth. While there were some limitations to the statistics, I believe that this was a thorough and unbiased examination of a complex dataset. Future program evaluation research of pediatric weight management programs should consider incorporating growth trajectories to examine change over time.

Conclusion

To my knowledge, this was the first study to examine the bidirectional association between body esteem and program outcomes of a pediatric weight management program

over time. During two years in a family-based weight management program, there were improvements in restrained eating behaviours and quality of life among youth. Body esteem was related to emotional eating and quality of life at baseline but not throughout treatment. Body esteem, BMI, disordered eating, and quality of life did not appear to systematically 'move together' over time. It is possible that the lack of association between initial body esteem and change in mental and physical health outcomes is due to the impact of unmeasured explanatory factors (e.g., family cohesion, mental health, weight-based teasing) that were not examined in the present study. Additionally, body esteem did not change over time. This could be due to the nature of the body esteem scale or, it may indicate that body esteem is a relatively stable construct. More research is needed about the nuances of body esteem and body image in pediatric weight management as it remains unclear how and when body image should be incorporated into treatment. The initial association of body esteem with disordered eating and quality of life indicates that there is a link between these variables and more research is needed to capture the complexity of these variables throughout weight management.

General Discussion

This research examined the role of body image in relation to BMI and obesity management through a meta-analysis and quantitative study. There is substantial research indicating a link between BMI and body image in youth (Austin et al., 2009; Loth et al., 2015; Shriver et al., 2013). However, there has not been a thorough examination of the literature to determine the degree of this association across youth of all BMI categories. Additionally, body esteem has not been longitudinally examined as a key factor in pediatric obesity management. Studying body image within the framework of obesity

management is vital as youth with obesity experience significant weight stigma that can impact their body image development which can negatively impact overall physical and mental health (Emmer et al., 2020; Wu & Berry, 2018).

The results from the present research indicate that the association between BMI and body image is complex, and there may be a place for body image in weight management programs as it has been associated with negative health outcomes that can perpetuate obesity (such as disordered eating) and impact quality of life. Findings from the current research studies have implications for (a) understanding the stability of specific constructs of body image (e.g., body esteem) across adolescence, (b) finding measurement and terminology consensus among body image researchers, and (c) the need for early body image intervention and best practices to incorporate body image into obesity prevention.

The current quantitative study found that body esteem did not change significantly during the first two years in a weight management program. A deeper inspection of the current literature suggests that body esteem may be a relatively stable construct within pediatric obesity (Gow et al., 2019), and within community youth with low body esteem (Lacroix et al., 2020). It is possible that body esteem is not the only body image construct that is stable in adolescence, as there has been evidence to suggest that body dissatisfaction is also resistant to change in youth with eating disorders (Gusella et al., 2003). Therefore, body image (particularly, body esteem and dissatisfaction) may be difficult to change, especially in samples of youth with eating and weight disorders without direct body image intervention. This does not suggest that body

image is unimportant in obesity research but rather there may be a critical period for intervention.

Research on obesity and eating disorders has found that the critical periods for developing these diseases are childhood and puberty, respectively (Dietz, 1998; Klump, 2013). Other research suggests that the critical period for body image development could be as early as childhood or pre-puberty (Wang et al., 2019). A large population-based study of youth examined body image trajectories over 15 years and found varying trajectories of body dissatisfaction over time (Wang et al., 2019). The most common trajectories among youth were consistently high or consistently low body dissatisfaction – and 95% of youth had little to no change in body dissatisfaction over time, indicating that body dissatisfaction might be relatively constant from adolescence to adulthood. This suggests that body dissatisfaction may be largely determined before the age of 14 (Wang et al., 2019).

In the current study, the average age of participants at baseline was 13 years old and body esteem did not change over time in these youth, echoing the results of Wang and colleagues (2019), that body image perceptions may be relatively stable after this age. Therefore, it might not be appropriate to evaluate body image as an indicator of obesity treatment efficacy in adolescents unless there is direct component of the intervention that targets body image.

Having consistently high body dissatisfaction has been associated with higher depressive symptoms, lower self-esteem, lower parent communication and caring, more peer dieting, and higher weight teasing than for youth who reported consistently low body dissatisfaction (Wang et al., 2019). Research has also found that low body

satisfaction between ages 12-15 predicts more dieting, unhealthy weight control behaviours, and increased binge eating in youth five years later (Neumark-Sztainer, Paxton, et al., 2006). Given evidence for a critical age for body image development, coupled with the fact that a negative body image is associated with eating disorders, obesity, and poor mental health, it is possible that early body image intervention is necessary to reduce the rates of these disorders (Ackard et al., 2002; Neumark-Szatiner, Paxton, et al., 2006). This is not to say that adults with obesity are destined to lifelong body dissatisfaction, but intervening at younger ages could help combat societal body expectations and influences that yield chronic negative body image self-perceptions.

One study found promising results of a Health at Every Size (HAES) intervention with college students (Humphrey et al., 2015), finding that adults can improve their body image, at least short-term. After the HAES intervention, researchers found significant improvements in intuitive eating, appearance and weight esteem, and anti-fat attitudes, and a reduction in dieting behaviours (Humphrey et al., 2015). These results have been mirrored in other studies with adults that follow a HAES or non-diet approach to improving the lives of people with higher average weight (Begin et al., 2018; Clifford et al., 2015; Ulian et al., 2018), suggesting that direct interventions to target body image can lead to short-term improvements in body dissatisfaction, and physical and mental health among adults. Future research should examine long-term follow-ups for people who attend HAES-based interventions to determine if there are sustained positive effects from these programs.

The results from the current meta-analysis indicated that the association between BMI and different body image constructs is variable; and sex differences are stronger or

weaker depending on the body image construct that was measured. There is a need for clearer operationalization of body image variables and the measurements that accompany each construct. It is evident that using 'body image' as a blanket term is not appropriate as there are clearly differences in how these constructs and measures are related to BMI, and possibly other important psychosocial constructs. This finding mirrors the opinions of a reflection article that consolidated transcripts from an expert panel at the 'Appearance Matters' conference in 2016 (Atkinson et al., 2020). A common theme among presenters included a call for consolidation and consensus among researchers and experts about the number of terms and measurement tools being used in body image research. Additionally, they highlighted how the variety of terms and measures that are available make it difficult to make comparisons across research areas and studies.

The results of the current meta-analysis could be a first step in consolidating terminology and measurement. Arguably the most impactful finding was the difference between Likert scales and figure rating scales. This finding suggests that Likert scales and figure rating scales are not measuring the same construct of body (dis)satisfaction, as the meta-analysis indicated a significant difference in the correlation of these two measures with BMI. Additionally, the association between figure rating scales (i.e., body distortion) and BMI did not demonstrate any sex differences which is a unique finding in body image research with community samples of youth with a wide range of weight categories.

It was difficult to categorize the body image studies in this meta-analysis as there was often a discrepancy between how the author(s) defined the body image construct and how they measured it (e.g., using a figure rating scale to measure body satisfaction).

Being able to develop a consensus on measurement and terminology would aid in providing more effective body image intervention programs and applying consistent techniques across different groups.

It is important to note that in the current meta-analysis "body distortion" was a term used to differentiate studies that used figure rating scales to assess "body (dis)satisfaction" from studies that used cognitive-evaluative or Likert scale measures to assess "body (dis)satisfaction." Although researchers indicated that they were measuring body dissatisfaction with both types of measures, it appeared that these two forms of evaluation are examining different constructs. A study of methodological problems with figure rating scales alluded to similar concerns (Cafri et al., 2010). Researchers suggested that when used in isolation, silhouette scales demonstrate poor reliability and ambiguity. For example, scale reliability is based on the extent to which participants select the same silhouettes ('actual' self and 'ideal' self) over time, rather than the absolute difference between the silhouettes. However, only difference scores are used in subsequent analyses.

Relatedly, certain information is lost by calculating a difference score between self and ideal body ratings (Cafri et al., 2010). Having participants choose a silhouette that represents their current body and one that represents their ideal body, are two different questions and it may not be appropriate to collapse them into one difference score. When used in research, figure or silhouette scales are conceptualized to assess body (dis)satisfaction. However, the difference score used in figure rating scales is not indicating *if participants like their body or feel good in their body* but instead, it is asking *if participants could choose any body they want, what would it be and how different is that from their current body perception?*

It would be more informative to see how each silhouette is related to psychosocial outcomes as their current figure could be compared to their BMI and body fat percentage to determine if they have accurate body perceptions. Research has found that people with higher average weight who slightly under-perceive their weight tend to have better psychosocial outcomes (Verzijl et al., 2018). Therefore, a person's perception of their current silhouette compared to their BMI might be more telling than a difference score between their current and ideal silhouette. A person's ideal silhouette might be more informative for dissatisfaction only if they have high internalization of societal body ideals. Consequently, it might not be accurate to assume that individuals who choose an ideal body that differs from their current self-perception are dissatisfied with their appearance. In fact, body appreciation and positivity research suggests that you can feel positively about your body while simultaneously wanting a smaller figure (Wood-Baraclow et al., 2010).

Conversely, figure rating scales also assume that when participants choose the same figure for their self and ideal body that they have no body dissatisfaction. However, it is possible that someone has 'achieved' their ideal figure through disordered behaviours such as frequent dieting, restrained eating, obsessive exercise, or purging; and continue to maintain these health-compromising behaviours due to a dissatisfaction with their appearance. A figure rating score for this person would be indicative of someone who is relatively satisfied with their body and appearance but that would be inaccurate.

Importantly, there are also issues with the many Likert scale measures available in the research and how they are being used to make conclusions about body image. In the current meta-analysis, there was significant heterogeneity between studies, even within

each body image construct. The remaining body image subcategories of the meta-analysis (i.e., appearance (dis)satisfaction, weight (dis)satisfaction, and body image) had significant variability. While the studies were categorized based on operationalization of construct and the measure used, there were a number of discrepancies between predictions, measurement, and conclusions drawn within each article. The most congruent category was the weight satisfaction category as each scale indicated that it was focused on how much an individual liked or disliked their weight or shape. The appearance subcategory was less homogeneous as it included scales that assessed how much an individual liked their overall appearance but also included scales that assess how much an individual liked each specific body part (e.g., stomach). Finally, the "body image" subcategory included any scale that assessed general or total body image, body esteem, or physical self-perceptions. This category had a weaker association with BMI, suggesting that perhaps specific aspects of body image are more related to BMI and weight than overall general body image perceptions.

The difficulties that were evident in categorizing studies in this meta-analysis were echoed in Atkinson and colleagues (2020, p.55) article about the future of body image research where one expert stated, "We drown newcomers to the field in a ridiculous plethora of constructs. Not only that, but… we talk about very similar things, but we call them by different names."

Future research should conduct qualitative interviews and focus groups with experts in the field to decide how body image terms are different, how they should be operationalized, and if there are certain constructs that are more suitable for specific populations. Once there is consensus about body image constructs, a next step would be

to conduct research that combines silhouette ratings with Likert scale measures to determine what aspect of body image is being measured with these different tools. This could be done by assembling diverse focus groups to determine what participants are thinking when they answer figure rating vs Likert scale questions, and collecting survey data to tease apart potential differences as they relate to common psychosocial outcomes associated with body image (e.g., disordered eating, self-esteem, mental health, quality of life).

Finally, it is important to address if, and how, body image has a place in obesity management. While obesity is largely related to genetics, metabolism, and other biological factors (Obesity Canada, n.d.), this does not mean that someone with obesity cannot be healthy (Blüher, 2020). Therefore, it is important that current pediatric programs focus on behavioural change rather than weight as these are malleable constructs while weight is largely stable. A key construct associated with health behaviours is body image (Cash, 2004; Smolak & Thompson, 2009; Neumark-Sztainer, Paxton, et al., 2006). The current quantitative study found associations between body esteem, emotional eating, and quality of life in a sample of youth in weight management. As mentioned earlier, it might be advantageous to incorporate an intensive body image intervention or education sessions (into weight management) beginning at a young age as body image might be the most malleable during childhood.

The development of body dissatisfaction appears to be tied to weight or BMI, therefore body acceptance may be an important avenue to promote from a young age to reduce chronic body dissatisfaction and the negative weight-related behaviours associated with it. Encouraging body acceptance and appreciation at a young age could help children

with obesity feel good in their current bodies and find ways to appreciate their bodies despite societal messages that suggest that bigger bodies are less healthy or less worthy.

A recent report indicated a need for more societal-level messaging about positive body image and body acceptance (Atkinson et al., 2020). It was suggested that more societal-level messages about health at every size could be beneficial to youth with obesity as it could decrease the amount of weight stigma they experience and potentially improve body image in all people (Atkinson et al., 2020). It is critical that there is a societal shift towards body acceptance and appreciation. Currently, having poor body image is so widespread (especially among women) that feeling negatively about one's body and appearance is considered 'normative discontent' (Matthiasdottir et al., 2012; Tantleff-Dunn et al., 2011). If society continues to spread the messages that only thin bodies are 'healthy' and 'attractive' and 'fat is bad,' it will perpetuate negative body image and make it difficult to encourage body appreciation and acceptance, especially in people with obesity.

Research indicates that experiencing weight stigma has negative implications for psychological well-being, body appreciation, and eating and exercise behaviours (Carels et al., 2019). However, body acceptance might be protective against weight stigma through normalizing larger body types. For example, a study of women with overweight found that those who attributed their overweight status to their biology or family history were less likely to internalize weight bias and had higher body shape satisfaction than women who did not think that their weight was related to their biology (Eisenberg et al., 2017).

Body acceptance could also have implications for improved mental health. A study of college students found that greater body positivity was associated with lower depressive symptoms (Kaufman et al., 2020). Additionally, Health at Every Size interventions have found that acceptance of diverse bodies is associated with less disordered eating and increases in body esteem (Humphrey et al., 2015). Therefore, normalizing larger body types and embracing body positivity might improve mental health among people with obesity.

Accepting body diversity may also lead to less disordered eating in youth with obesity. A study of adults with overweight and obesity found that those who under-perceived their weight had less uncontrolled and restrained eating than those who accurately perceived their weight status across all levels of obesity (Verzijl et al., 2018). Other research has found similar trends with adolescent (Deschamps et al., 2015) and young adult samples (Sonneville et al., 2016). A qualitative study of 20 adolescents demonstrated their plea for society to embrace the body positive movement to reduce weight stigma, specifically in the online environment (Zavala, 2018, p.6), "…I don't think people understand that the body positive movement is all about just not hating yourself…" Therefore, 'normalizing' larger bodies and promoting body diversity may be important in improving disordered eating and quality of life for youth with obesity.

This study provides further evidence for the complex nature of the association between body image and BMI. The present thesis found discrepancies in research about the relevance of different body image constructs in relation to BMI. Generally, the meta-analytic results indicated that youth with higher BMIs have lower body image, higher disordered eating, and lower quality of life. This confirms the negative impact of

overweight and obesity on the physical and mental health of youth. However, the association of these variables in clinical populations throughout weight management remains unclear.

Body image appears to be relatively stable after adolescence and may require targeted intervention to see improvements among youth with obesity. Findings show that a two year weight management program can be advantageous for improving restrained eating behaviours and quality of life. However, more research is needed to determine how and when body image should be incorporated into treatment.

The present studies have implications for body image development, finding a consensus about body image measurement and terminology, and potential avenues for incorporating body image intervention into obesity management. Societal values around appearance ideals need to change to foster body appreciation and acceptance among youth with obesity to improve mental and physical health into adolescence and adulthood. It is critical that researchers and clinicians continue to examine body image development, find ways to promote health at every size, and begin deconstructing current appearance ideals to improve the quality of life of people with obesity.

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Appendix A - Search Strategy Example

Web of Science search strategy

TI=(obesity OR "weight status" OR "body mass index" OR bmi) AND TI=("body image" OR "eating behav*" OR "quality of life") AND TS=(child OR adoles*) NOT TS=("bariatric surgery" OR "randomised control trial")

Filter: English, 1973

Appendix B – Screening Manual

1. **Does this study include BMI or weight status?**

Each article must measure and report BMI (raw, standardized, or percentile) or weight status (i.e., average weight, overweight, obese).

2. **Does this study include adolescents or children?**

The sample must include children (6-12) or adolescents (preferably 13-18 but also accepted 13-25).

3. **Is there at least one outcome of interest reported?**

a) Body image: may include body esteem, body image, body (dis)satisfaction, weight esteem, appearance esteem, physical appearance esteem.

b) Quality of life: may include well-being, life satisfaction, health-related QOL

c) Disordered eating behaviours: emotional, external, restrained eating, unhealthy weight control behaviours, binge eating, dieting behaviour. Some measures may include: eating disorder examination questionnaire (EDEQ), binge eating, Dutch eating behaviour questionnaire (DEBQ), Eating attitudes test (Eat-26).

d) AVOID food/beverage intake forms i.e., consumption of sweet drinks or fatty foods

4. **Does this study include the appropriate statistics?**

This will be difficult to determine the first time around, but the abstract may say "examine the association between BMI and [insert outcome here]." To be included in the

final sample of studies, results had to include correlations between BMI and one of the outcomes.

5**. No intervention or treatment programs should be included in the research.**

Regardless of what the intervention or treatment is for, do not include, as this meta-analysis only includes a normative community sample.

6. **No samples of people with diagnosed eating disorders or those who have had bariatric surgery or special populations.**

Sample cannot include patients diagnosed with anorexia, bulimia, binge eating, or those who have undergone bariatric surgery, or those who are from a special population (e.g., diabetes clinic patients, Prader Willis syndrome, cystic fibrosis, downs syndrome).

7. **Studies need to be written in English.**

8. **Unusable for any reason: additional reasons a study may be excluded.**

Cannot use commentary papers, systematic reviews, the paper focus on weight/BMI, not enough detail to code the study.

Appendix C – Coding Manual

1. Study Name _____
2. Year of publication ____
3. Type of publication: a) peer-reviewed b) dissertation/thesis
4. Sample size ____
5. Percentage female _____
6. Sex of sample: a) female b) male c) both
7. Average age of participants _____
8. Location of study _____
9. Ethnic majority of the sample _____
10. BMI reported a) raw bmi b) zBMI c) BMI percentile d) weight category
11. Average BMI of the sample _____ (if another BMI report was used then the average was recorded here)
12. Percentage of sample that is of average weight _____
13. Construct measured _____
14. Scale used _____
15. Alpha of the scale used_____
16. Correlation between BMI and outcome _____
17. p-value of the correlation _____
18. Type of correlation used _____

19. Study quality questions (National Heart, Lung, and Blood Institute Quality Assessment Tool for observational cohort and cross-sectional studies https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools)

    a. Was the research question or objective in this paper clearly stated?
    b. Was the study population clearly specified and defined?
    c. Was the participation rate of eligible persons at least 50%?
    d. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?
    e. Was a sample size justification, power description, or variance and effect estimates provided?
    f. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?
    g. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?
    h. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?
    i. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?
    j. Was the exposure(s) assessed more than once over time?
    k. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?
    l. Were the outcome assessors blinded to the exposure status of participants?
    m. Was loss to follow-up after baseline 20% or less?
    n. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?

Appendix D - Meta-analysis Glossary of Terms

Body image constructs	
Term	Definition
Body image	One's psychological experiences of the appearance and functioning of one's body (Cash & Pruzinsky, 1990); included general feelings about one's body and/or appearance
Appearance (dis)satisfaction	One's feelings about one's appearance and body (positive or negative)
Weight satisfaction	One's overall feelings about one's weight/how weight impacts one's mood
Body distortion/perception	Overall body distortion scores to represent one's discrepancy between their actual and ideal body (through figure rating scales)
Disordered eating constructs	
Term	Definition
Restrained eating	Eating less than desired to lose or maintain body weight (Van Strien & Oosterveld, 2008).
Emotional eating	Eating in response to negative emotions or using food as a coping mechanism to deal with emotions (Van Strien & Oosterveld, 2008).
External eating	Eating in response to your surroundings (e.g.,the sight or smell of food; Van Strien & Oosterveld, 2008).
Unhealthy weight control behaviours	Meal skipping, laxative use, and self-induced vomiting, excessive dieting (Neumark-Sztainer, Wall, Story, & Perry, 2003).
Binge eating; Loss of control eating	The consumption of an objectively large amount of food accompanied by a sense of loss of control; feeling one cannot stop eating or control how much one is eating (Smith, Orcutt, Steffen, *et al.* 2019)

General eating disorder symptoms	Symptoms/patterns of behaviours of anorexia or bulimia, e.g., vomiting, restricting food intake

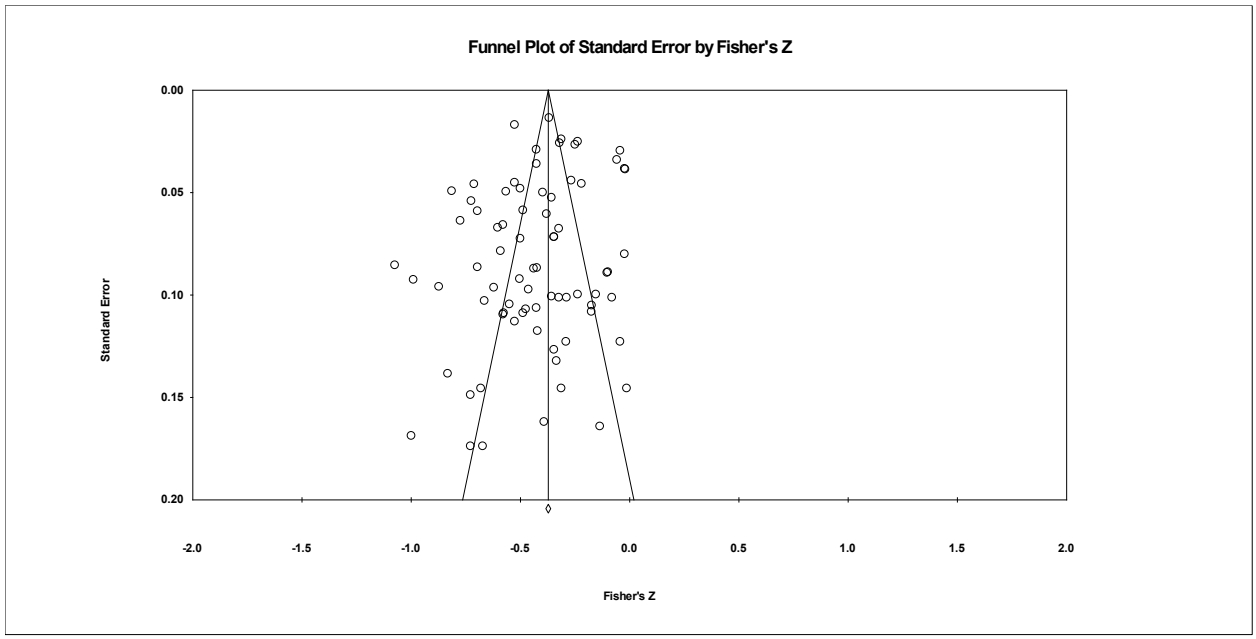
Quality of life (QOL) constructs

Term	Definition
Total QOL	Cumulative score of quality of life based on subscales of physical, social, emotional and school health
Physical	Assessing difficulty with everyday physical activities e.g., running, walking up stairs, bathing, doing chores, lifting things
Psychosocial	Cumulative score of emotional, social, and school functioning
Emotional	Assessment of frequency of emotions such as sadness, anger, fear, worry, and sleeping difficulty
School	Assessing school focus, forgetfulness, difficulty, missing school for health reasons/appointments
Social	Degree of difficulty getting along with peers, teasing victimization, and making friends

Appendix E – Funnel Plots

Figure E1

Funnel plot for observed effect sizes of the association between BMI and overall body image



Note. No additional studies were added to the random-effects model

Figure E2

Funnel plot of observed studies of appearance satisfaction and BMI

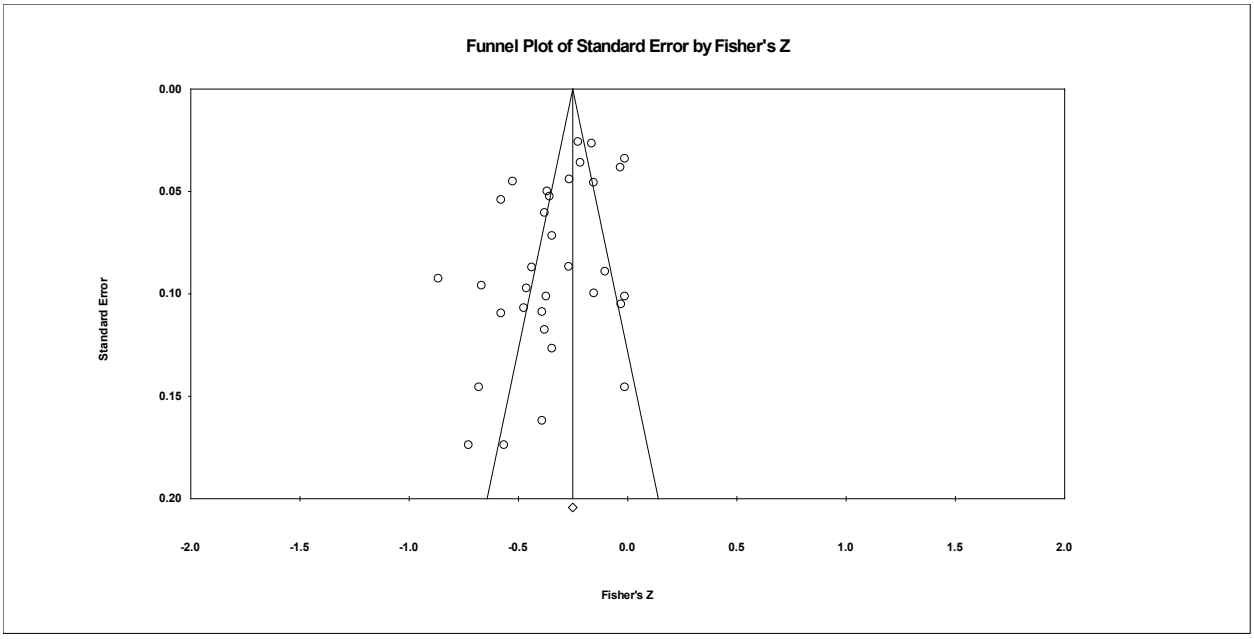


Figure E3

Funnel plot with imputed studies for appearance satisfaction and BMI

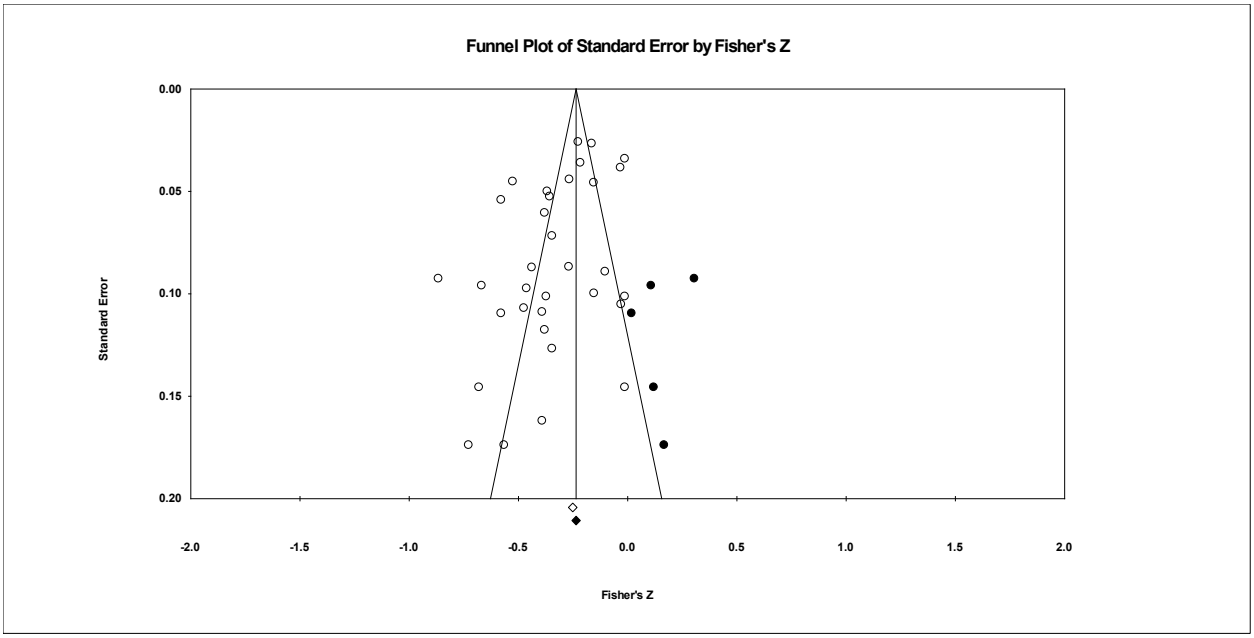


Figure E4

Funnel plot for observed studies for body distortion/perception and BMI

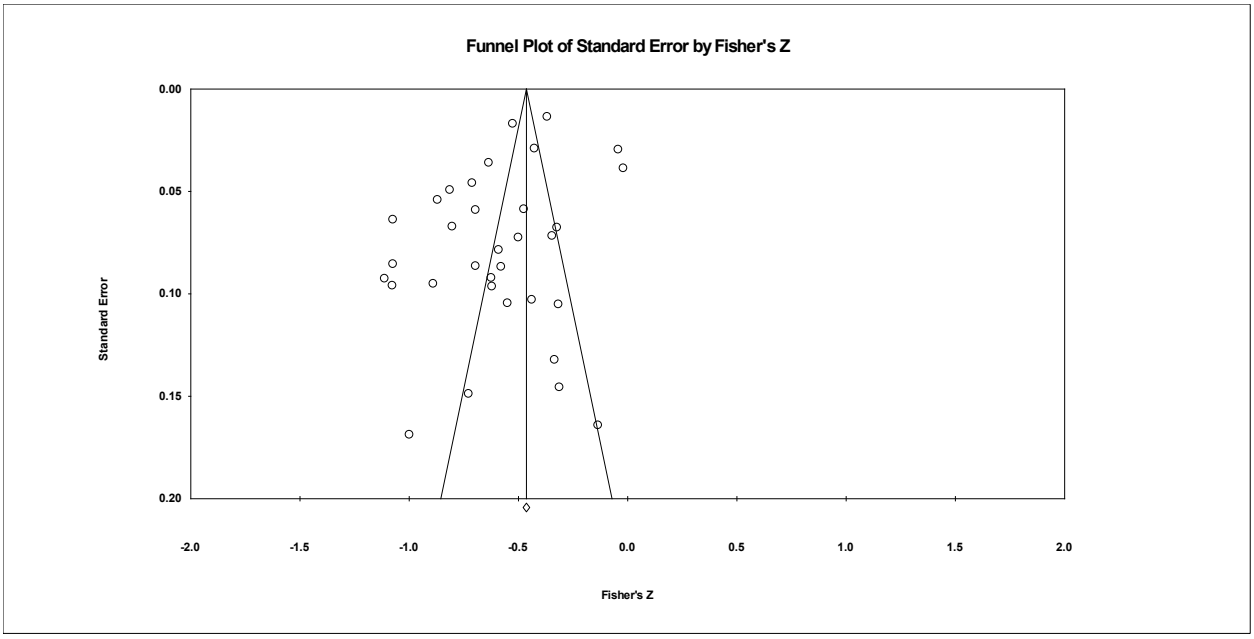


Figure E5

Funnel plot for observed studies for weight satisfaction and BMI

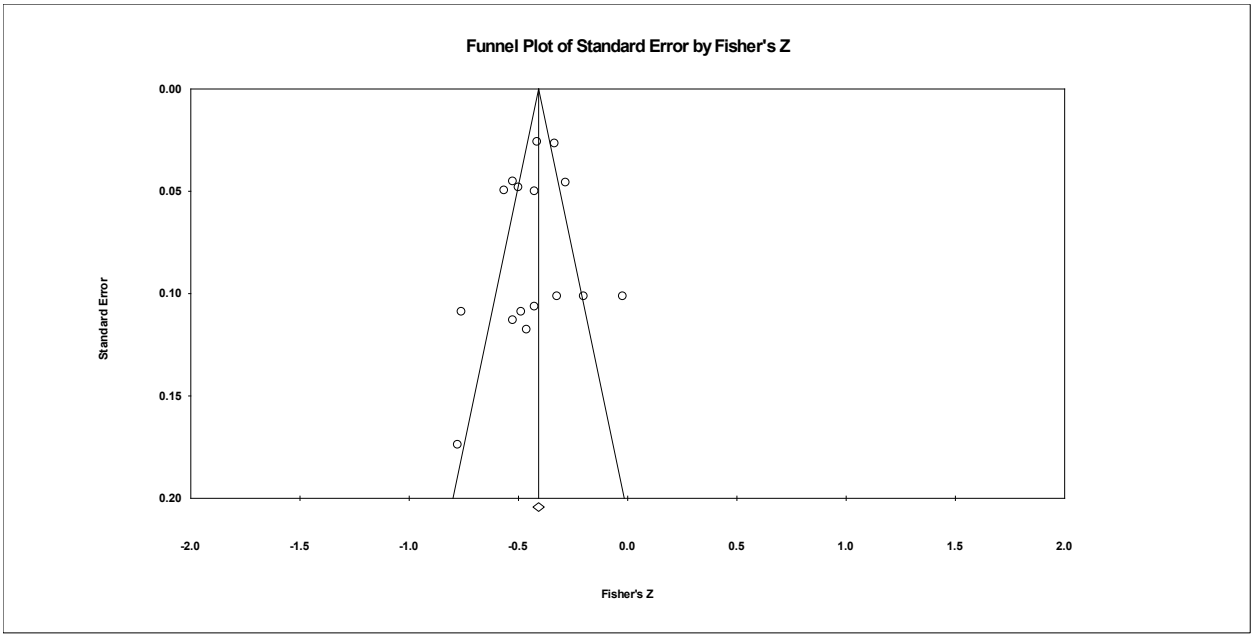


Figure E6

Funnel plot with imputed studies for weight satisfaction and BMI

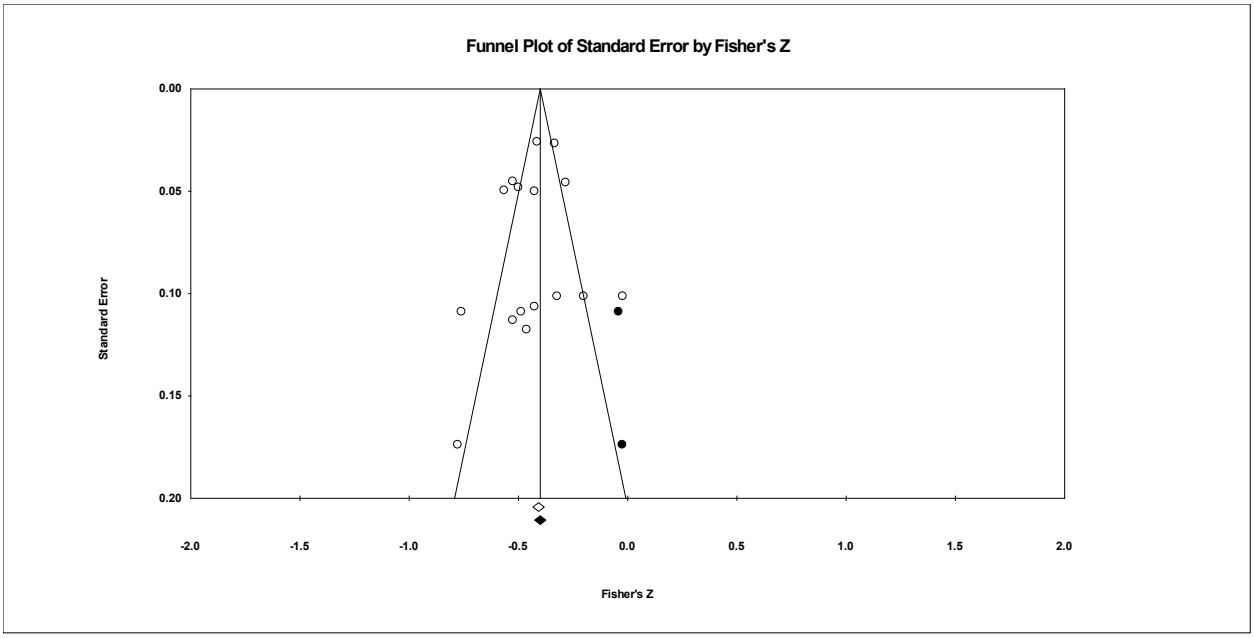


Figure E7

Funnel plot of observed studies for body image and BMI

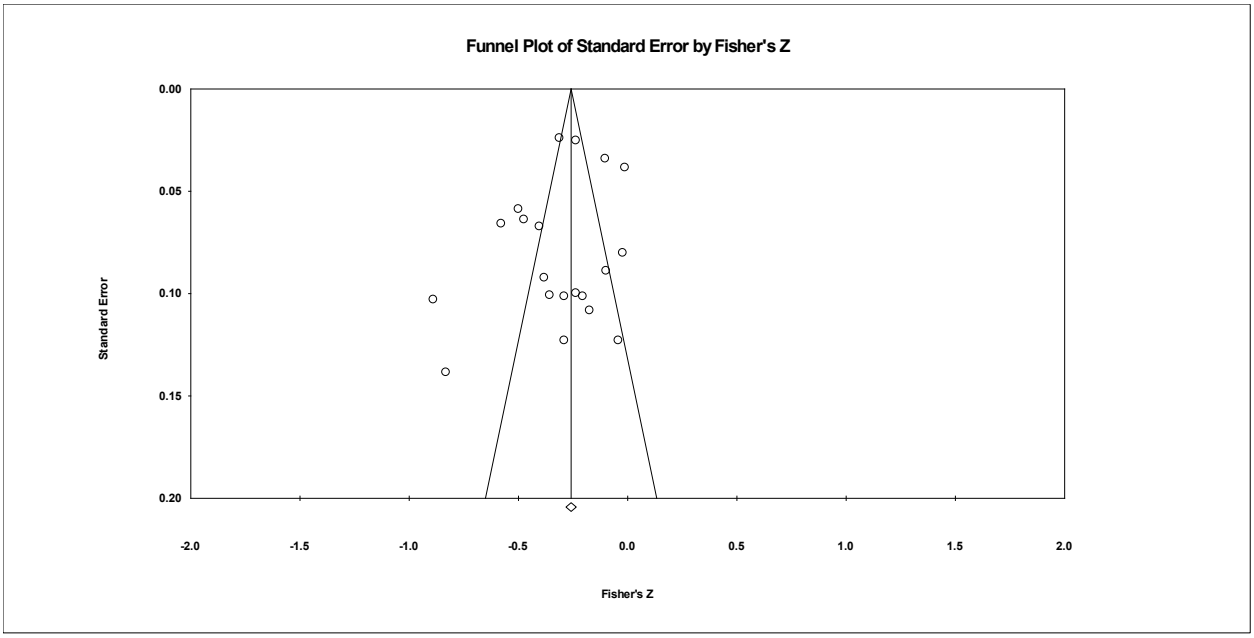


Figure E8

Funnel plot with the imputed values of body image and BMI

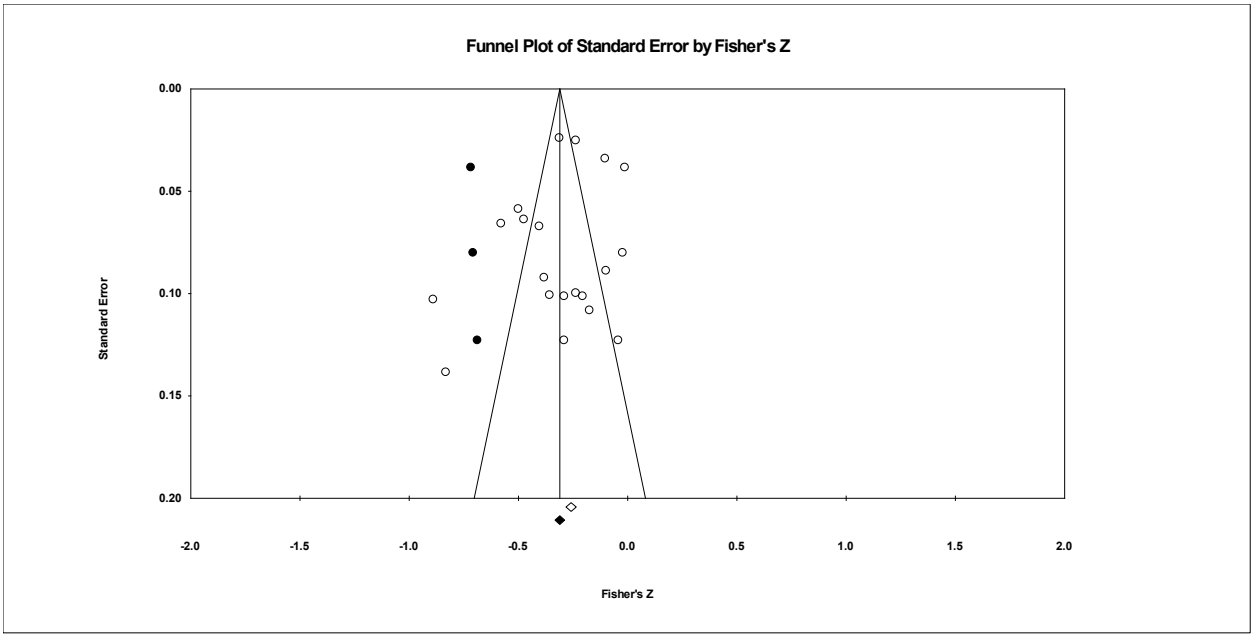


Figure E9

Funnel plot with the observed values of disordered eating and BMI

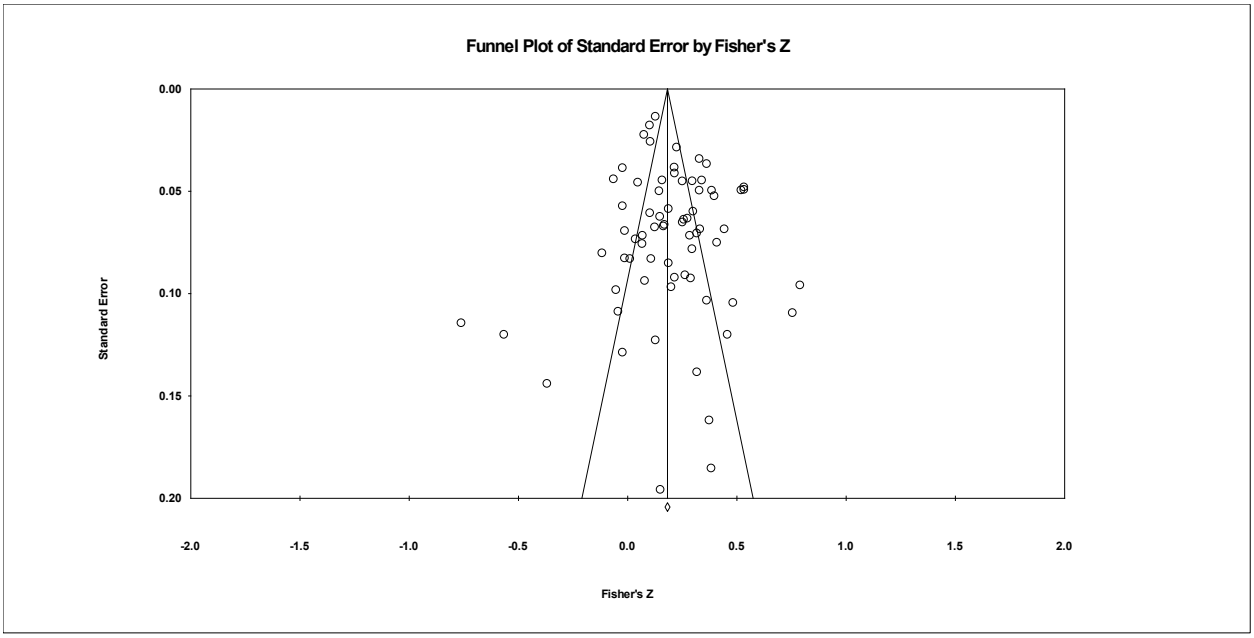


Figure E10

Funnel plot with the imputed values of disordered eating and BMI

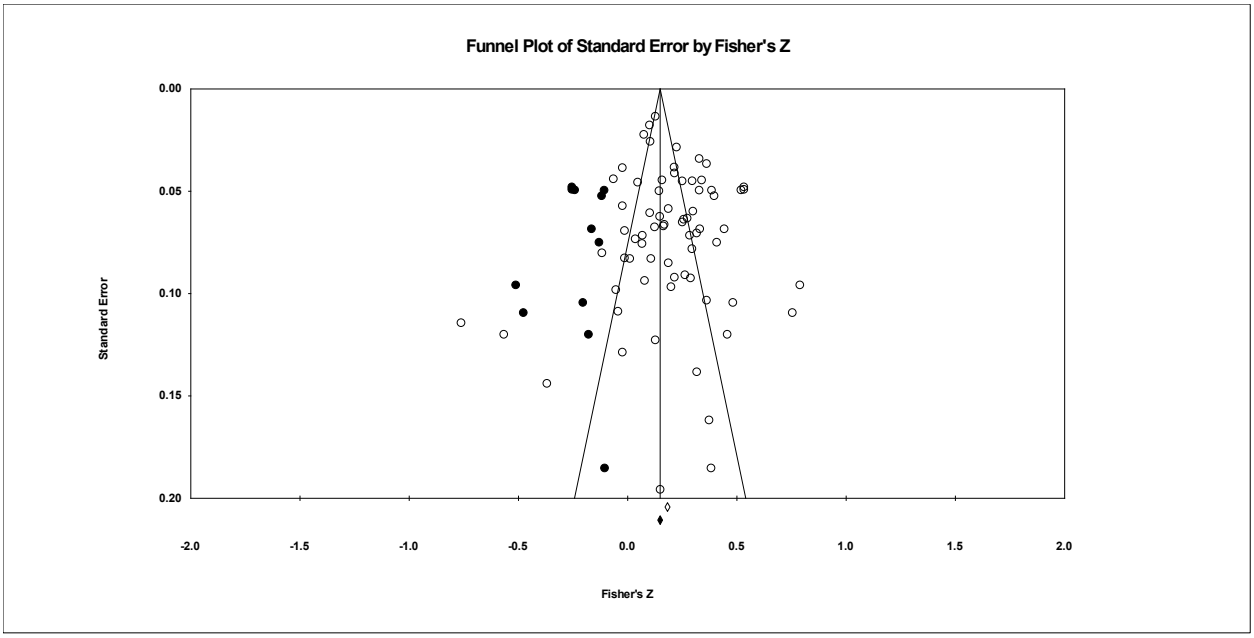


Figure E11

Funnel plot with the observed values of restrained eating and BMI

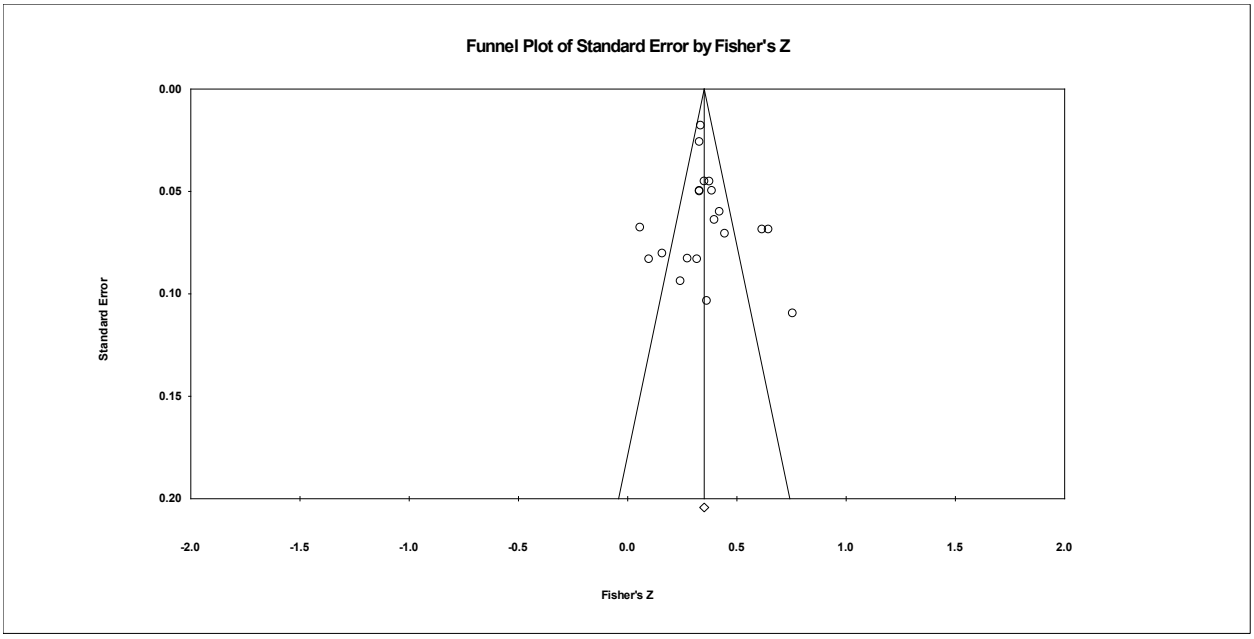


Figure E12

Funnel plot with the imputed values of restrained eating and BMI

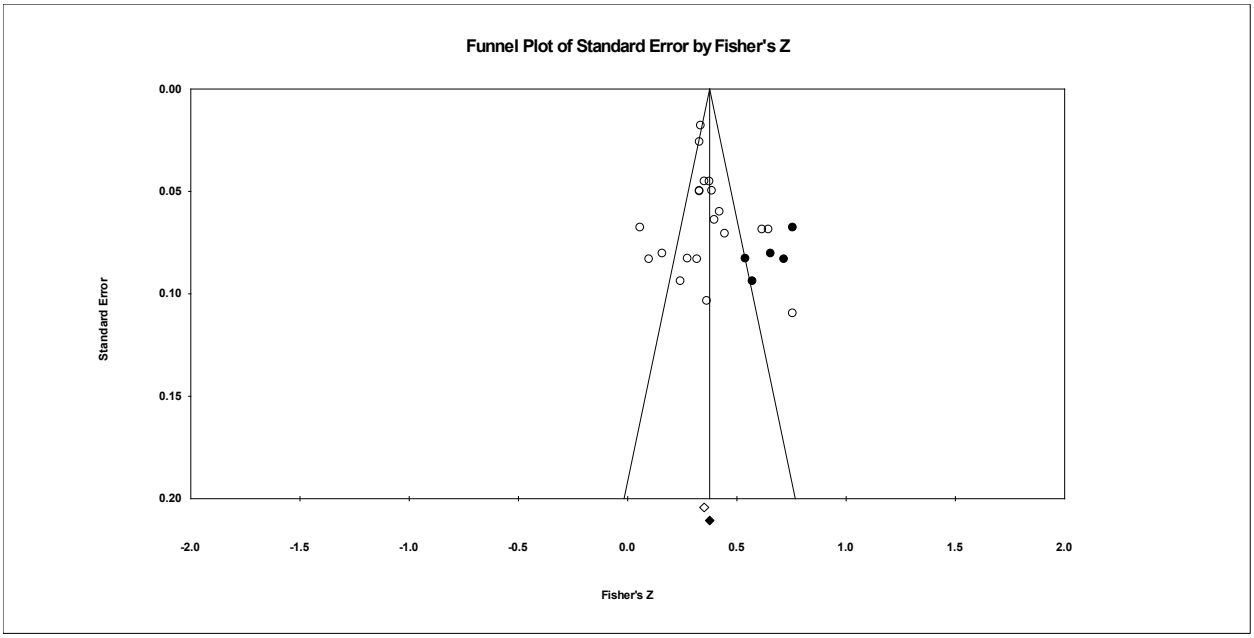


Figure E13

Funnel plot with the observed values of emotional eating and BMI

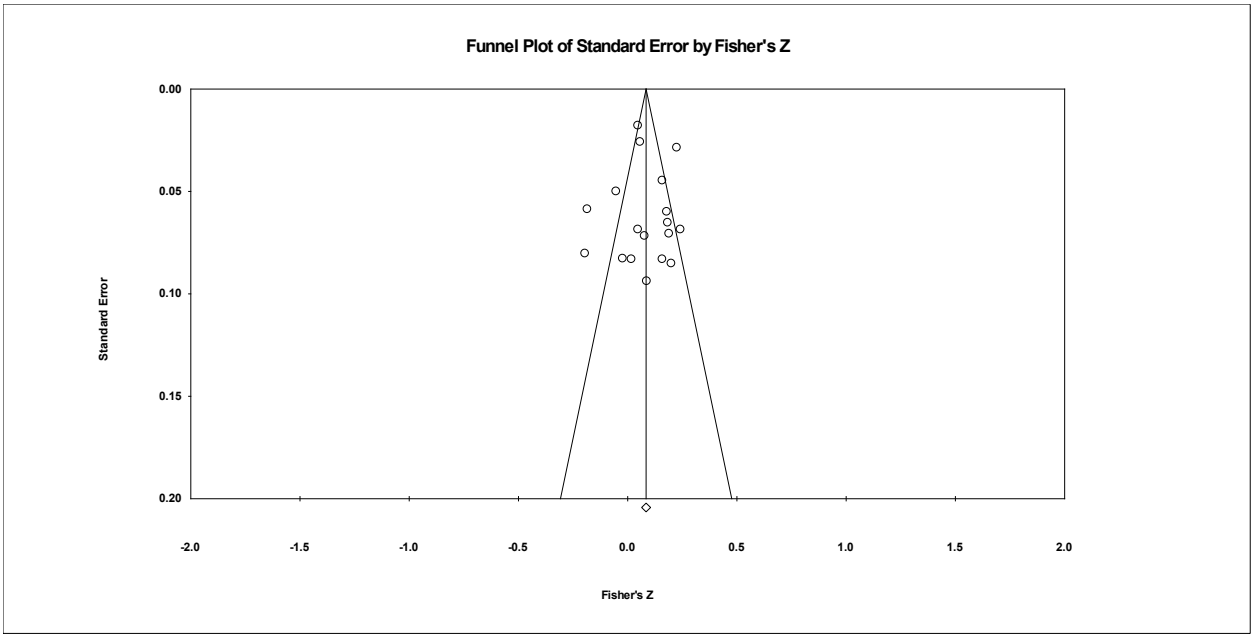


Figure E14

Funnel plot with the imputed values of emotional eating and BMI

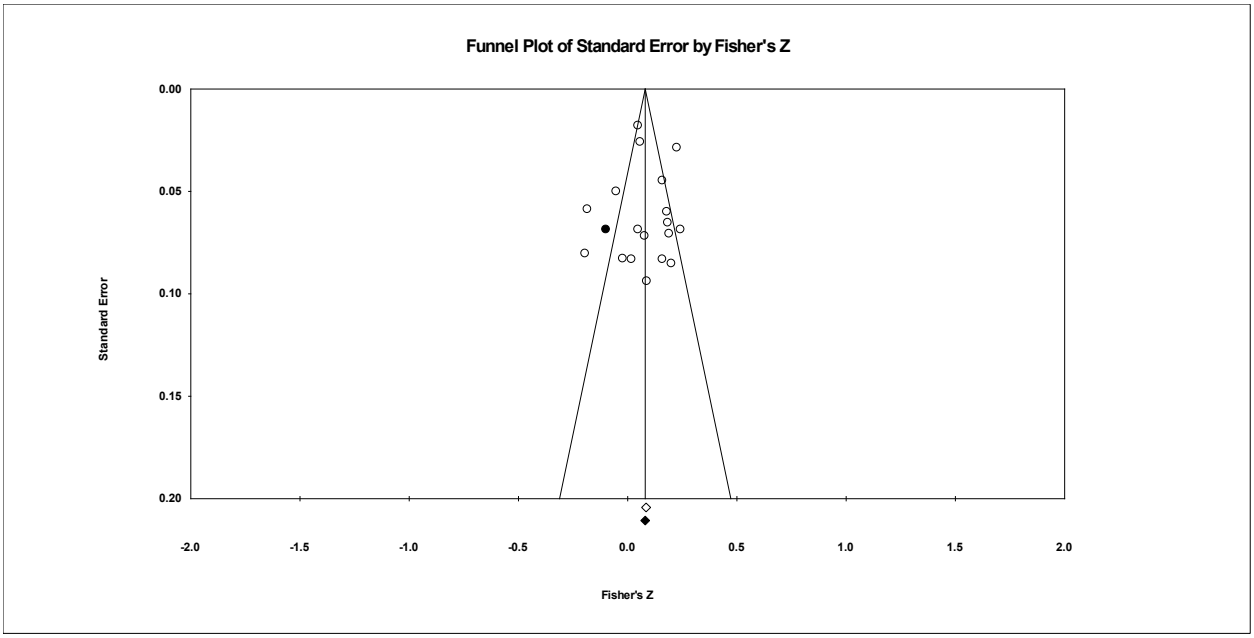


Figure E15

Funnel plot with the observed values of external eating and BMI

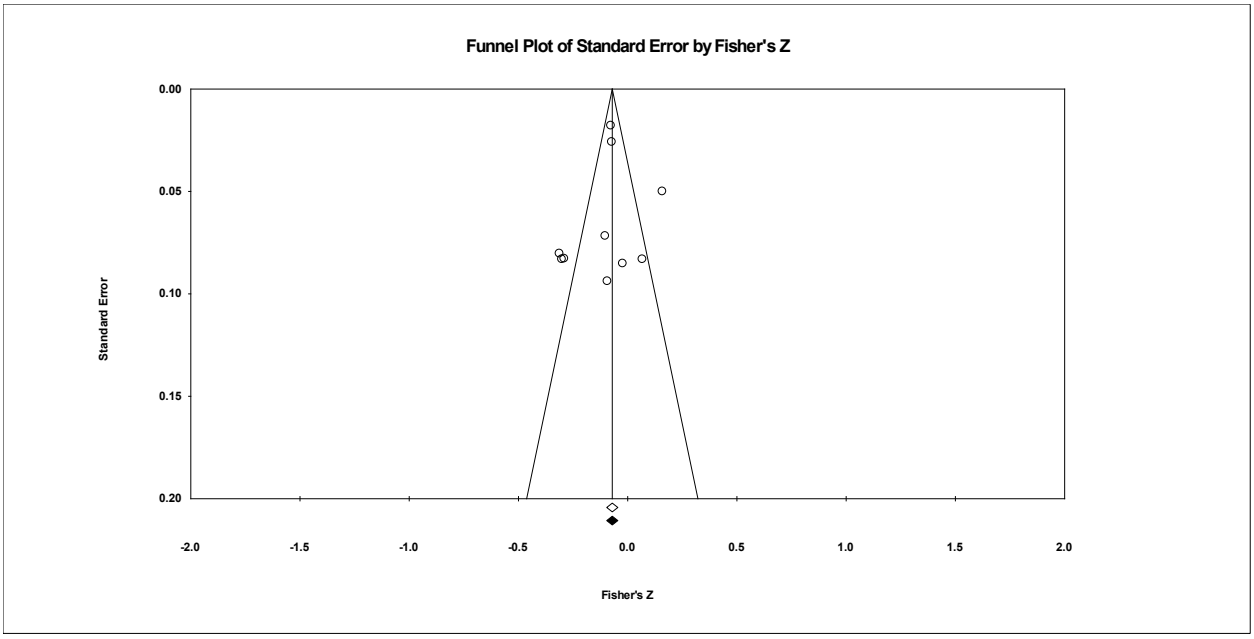
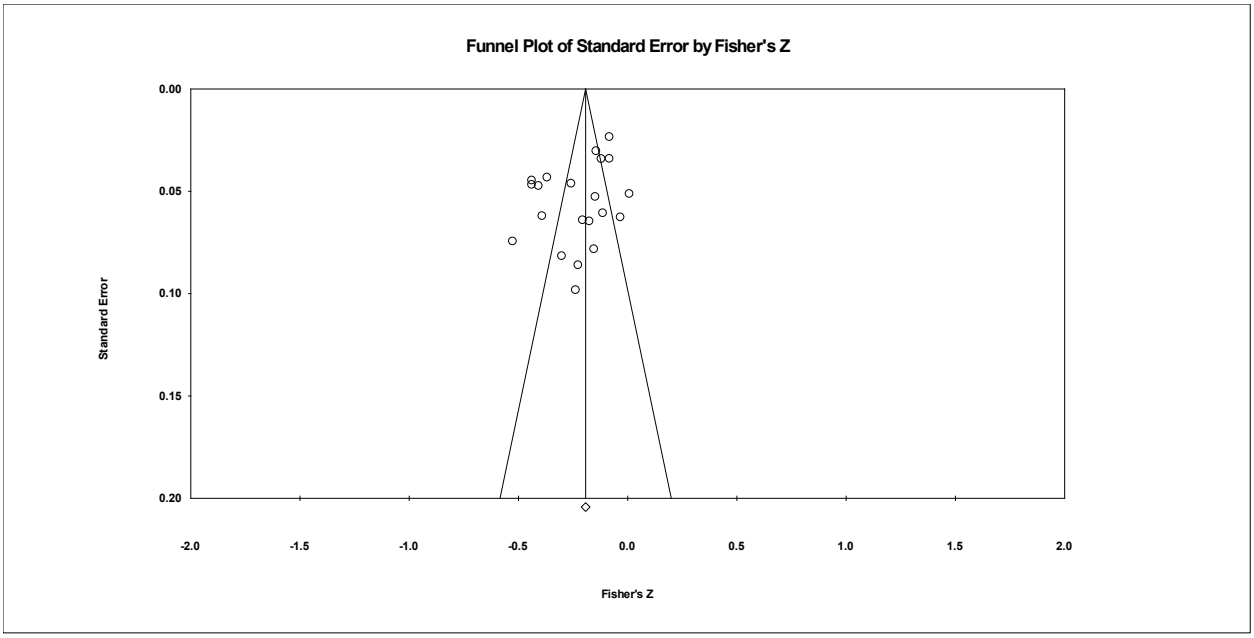


Figure E16

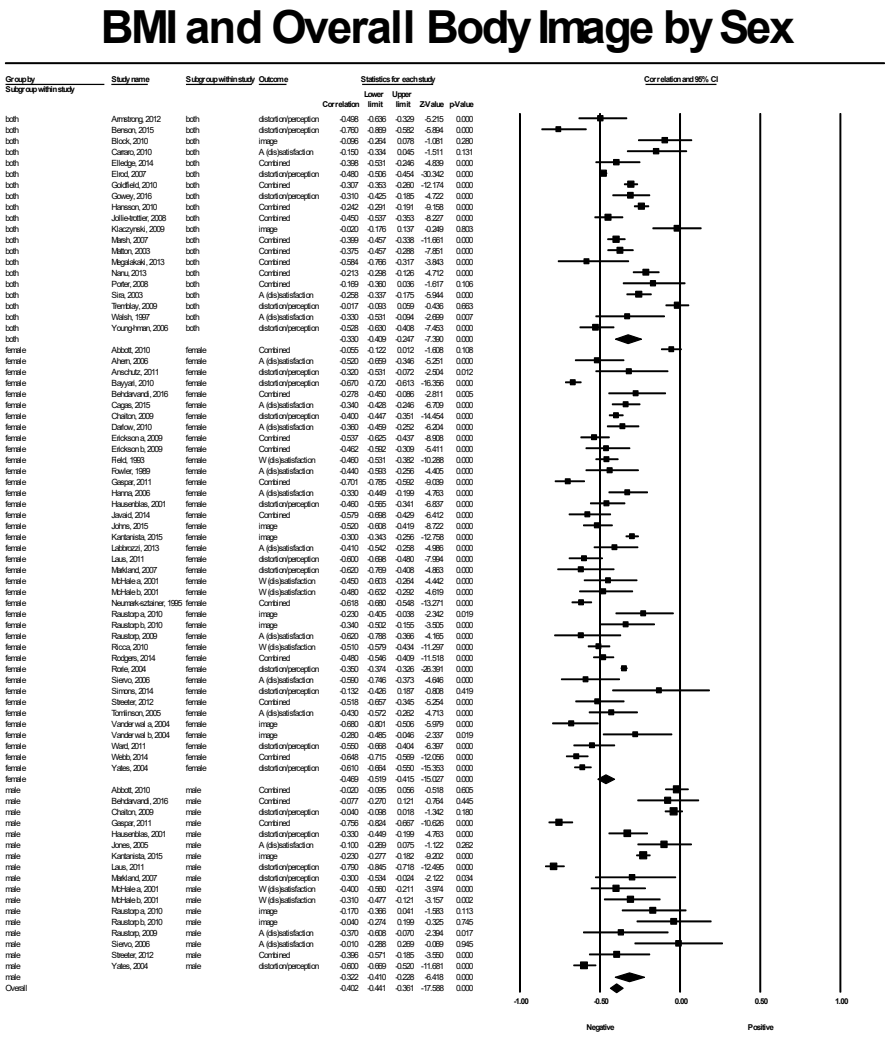
Funnel plot with the observed values of quality of life and BMI



Appendix F – Additional Forest Plots

Figure F1

Association between BMI and overall body image separated by sex



Random-effects model

Figure F2

Associations between BMI and body image separated by construct

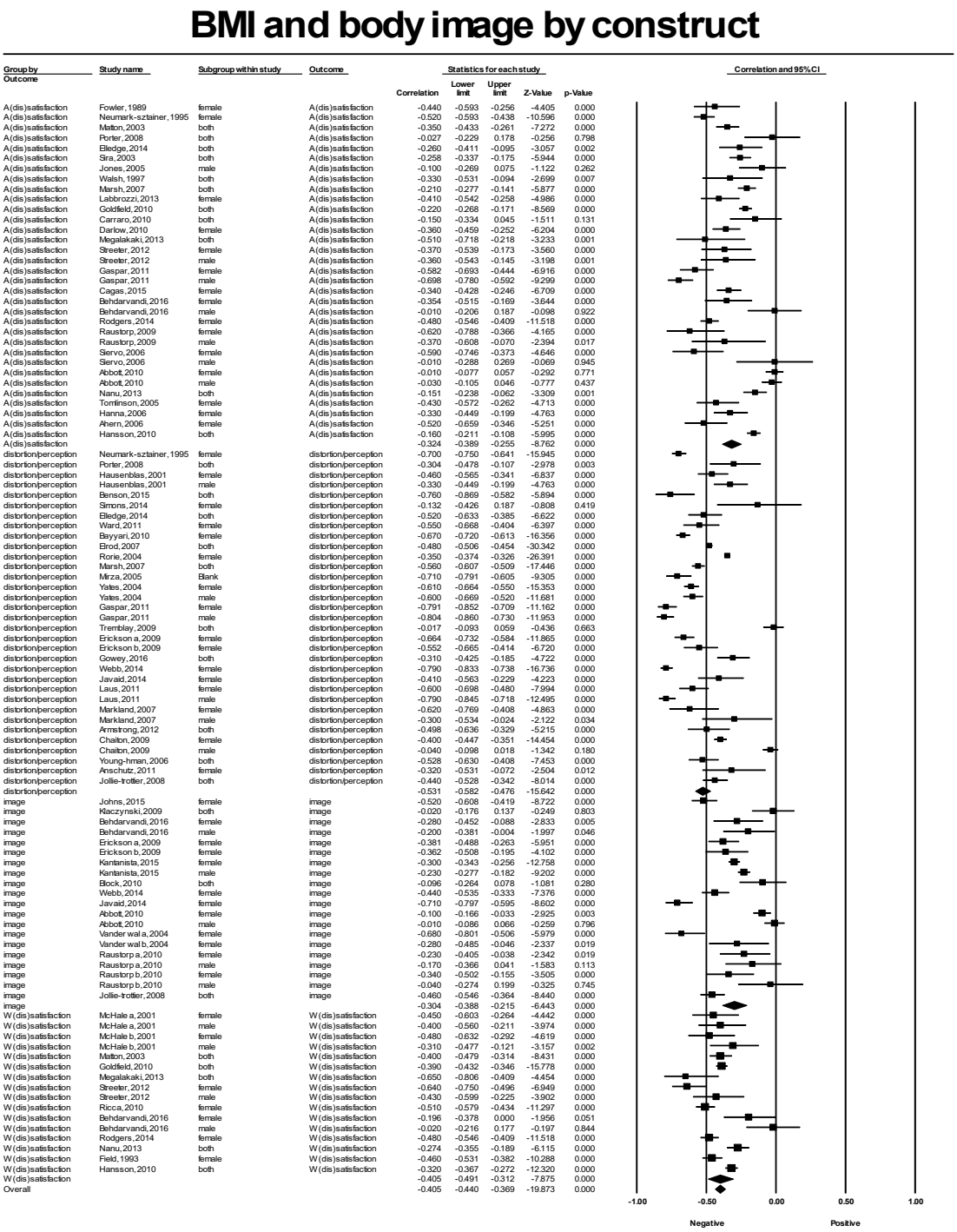
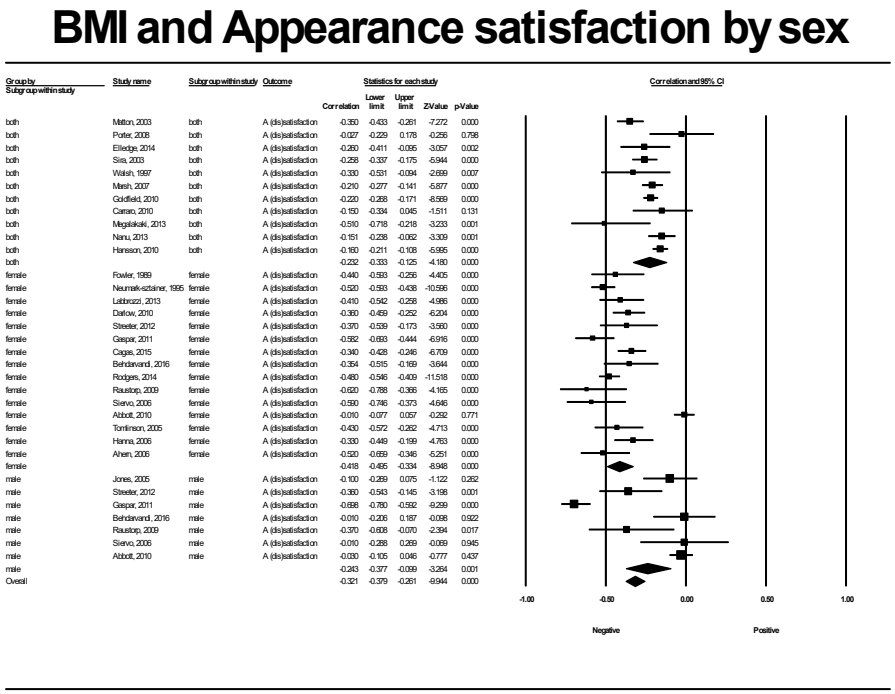


Figure F3

Association between BMI and appearance satisfaction by sex



Random-effects model

Figure F4

Association between BMI and weight satisfaction by sex

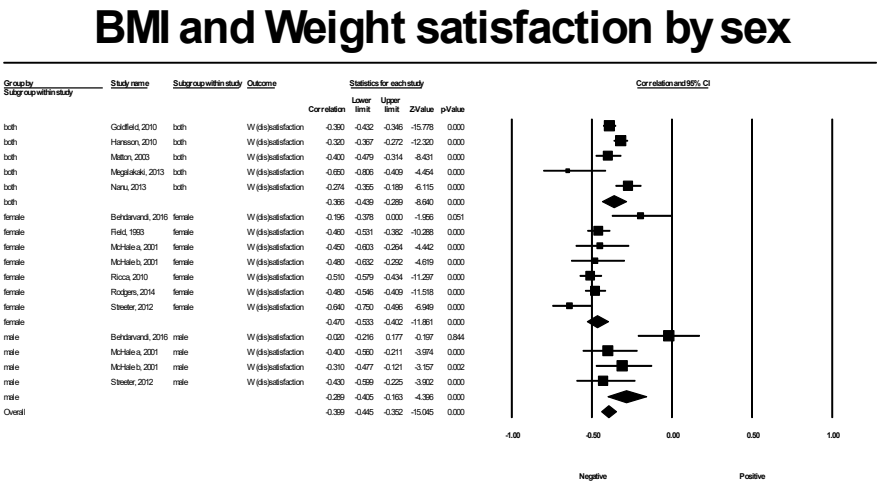


Figure F5

Association between BMI and body distortion/perception by sex

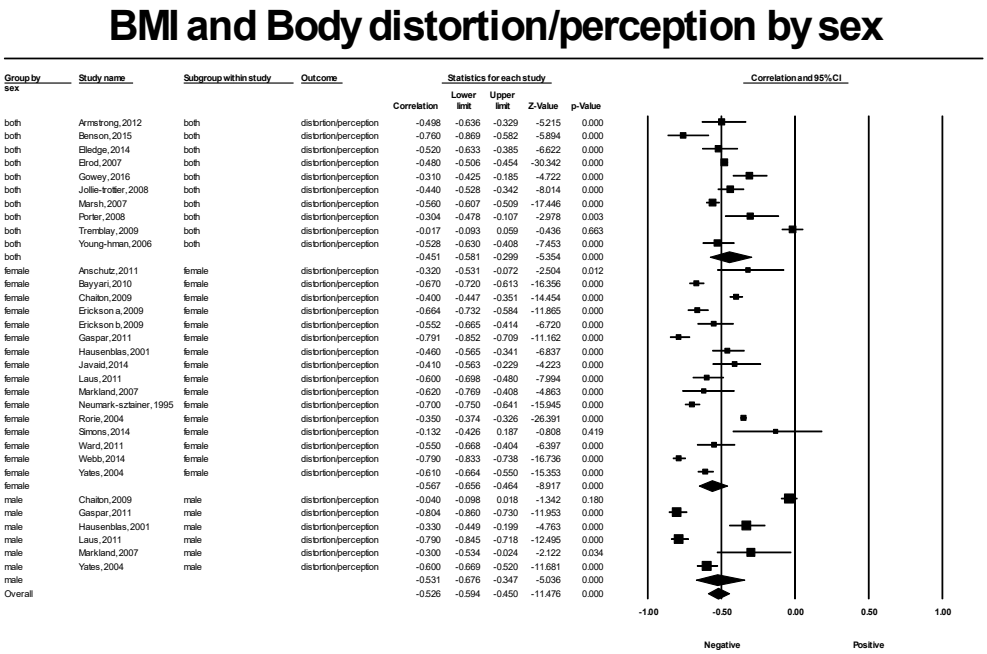


Figure F6

Association between BMI and body image by sex

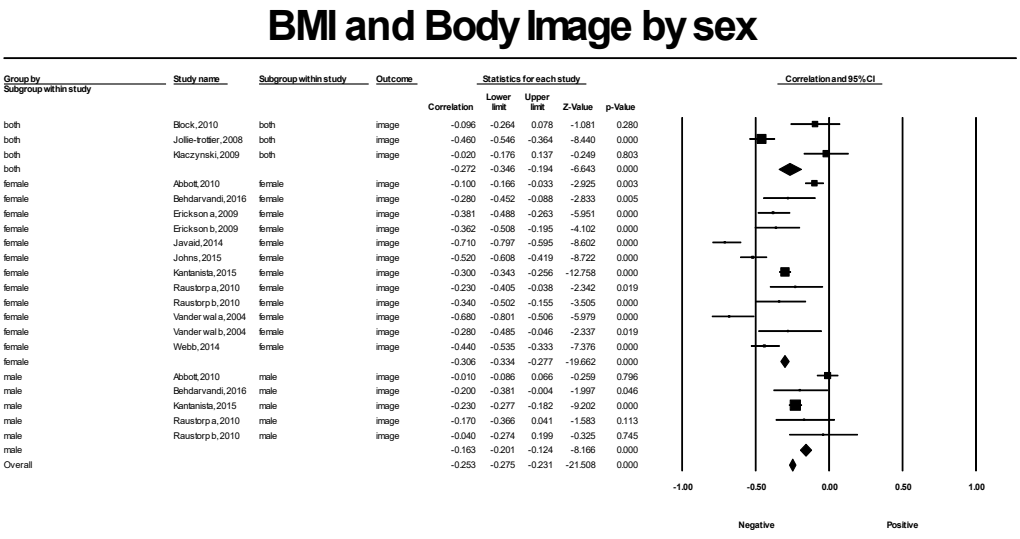
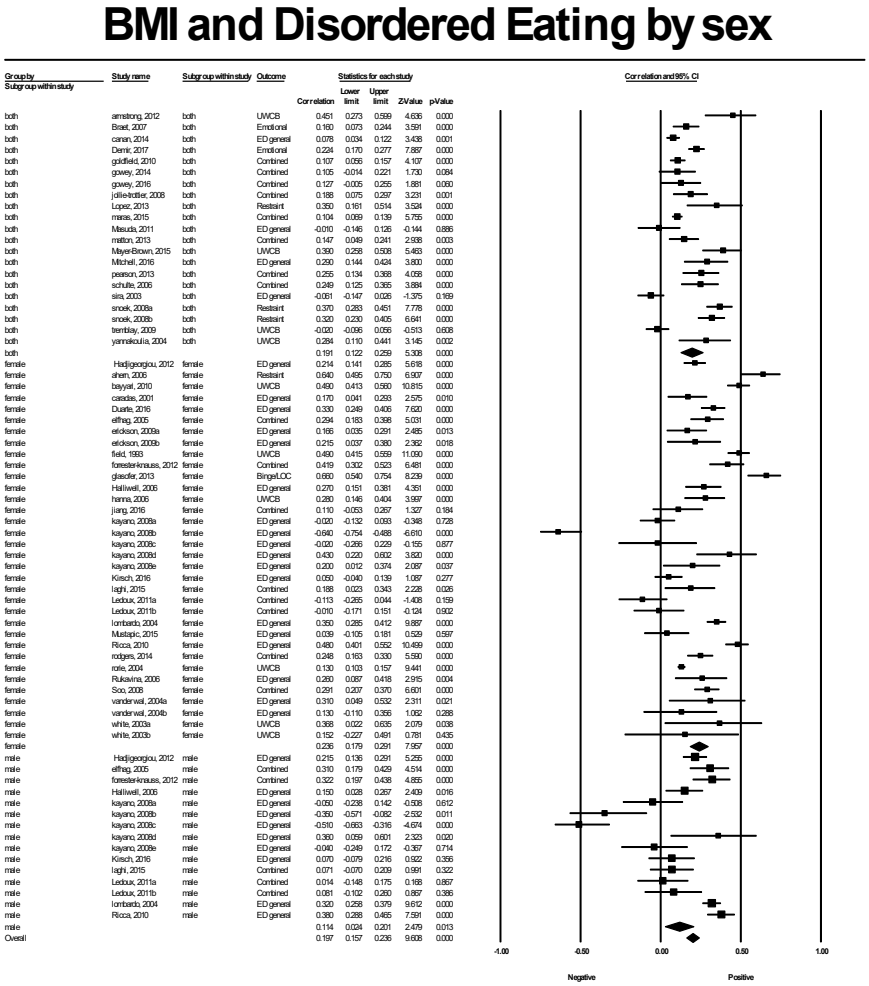


Figure F7

Association between disordered eating and BMI by sex



Group by Subgroup within study	Study name	Subgroup within study	Outcome	Correlation	Lower limit	Upper limit	ZValue	pValue
both	armstong, 2012	both	UWCB	0.451	0.273	0.599	4.636	0.000
both	Bissel, 2007	both	Emotional	0.160	0.073	0.244	3.591	0.000
both	canan, 2014	both	ED general	0.078	0.034	0.122	3.438	0.001
both	Demir, 2017	both	Emotional	0.224	0.170	0.277	7.897	0.000
both	goldfield, 2010	both	Combined	0.107	0.056	0.157	4.107	0.000
both	gowey, 2014	both	Combined	0.105	-0.014	0.221	1.730	0.084
both	gowey, 2016	both	Combined	0.127	-0.005	0.255	1.881	0.060
both	jolliffe-thiffer, 2008	both	Combined	0.198	0.075	0.297	3.231	0.001
both	Lopez, 2013	both	Restraint	0.350	0.161	0.514	3.524	0.000
both	marss, 2015	both	Combined	0.104	0.069	0.139	5.755	0.000
both	Masuda, 2011	both	ED general	-0.010	-0.146	0.126	-0.144	0.886
both	matton, 2013	both	Combined	0.147	0.049	0.241	2.938	0.003
both	Maye-Brown, 2015	both	UWCB	0.300	0.258	0.508	5.463	0.000
both	Mitchell, 2016	both	ED general	0.250	0.144	0.424	3.800	0.000
both	pearson, 2013	both	Combined	0.255	0.134	0.368	4.058	0.000
both	schulte, 2006	both	Combined	0.249	0.125	0.365	3.884	0.000
both	sira, 2003	both	ED general	-0.081	-0.147	0.026	-1.375	0.169
both	snoek, 2008a	both	Restraint	0.370	0.283	0.451	7.778	0.000
both	snoek, 2008b	both	Restraint	0.320	0.230	0.405	6.641	0.000
both	tremblay, 2009	both	UWCB	-0.020	-0.096	0.056	-0.513	0.608
both	yannakoulia, 2004	both	UWCB	0.284	0.110	0.441	3.145	0.002
both				0.191	0.122	0.259	5.308	0.000
female	Hadjigeorgiou, 2012	female	ED general	0.214	0.141	0.285	5.618	0.000
female	ahren, 2006	female	Restraint	0.640	0.485	0.750	6.937	0.000
female	bayyat, 2010	female	UWCB	0.490	0.413	0.560	10.815	0.000
female	cassidy, 2001	female	ED general	0.170	0.041	0.293	2.575	0.010
female	Duarte, 2016	female	ED general	0.330	0.249	0.406	7.620	0.000
female	elfhag, 2005	female	Combined	0.294	0.183	0.398	5.031	0.000
female	erickson, 2008a	female	ED general	0.168	0.035	0.291	2.485	0.013
female	erickson, 2008b	female	ED general	0.215	0.037	0.380	2.362	0.018
female	field, 1993	female	UWCB	0.490	0.415	0.559	11.090	0.000
female	forestier-knauss, 2012	female	Combined	0.419	0.302	0.523	6.481	0.000
female	glaesfer, 2013	female	BingeLOC	0.660	0.540	0.754	8.239	0.000
female	Halliwell, 2006	female	ED general	0.270	0.151	0.381	4.391	0.000
female	hanna, 2006	female	UWCB	0.280	0.146	0.404	3.997	0.000
female	jiang, 2016	female	Combined	0.110	-0.053	0.267	1.327	0.184
female	kayano, 2008a	female	ED general	-0.020	-0.132	0.093	-0.348	0.728
female	kayano, 2008b	female	ED general	-0.640	-0.754	-0.488	-6.610	0.000
female	kayano, 2008c	female	ED general	-0.020	-0.266	0.229	-0.195	0.877
female	kayano, 2008d	female	ED general	0.430	0.220	0.602	3.820	0.000
female	kayano, 2008e	female	ED general	0.200	0.012	0.374	2.097	0.037
female	Kirsch, 2016	female	ED general	0.050	-0.040	0.139	1.097	0.277
female	laghi, 2015	female	Combined	0.188	0.023	0.343	2.228	0.026
female	Ledoux, 2011a	female	Combined	-0.113	-0.265	0.044	-1.408	0.159
female	Ledoux, 2011b	female	Combined	-0.010	-0.171	0.151	-0.124	0.902
female	lombardo, 2004	female	ED general	0.350	0.285	0.412	9.897	0.000
female	Mustapic, 2015	female	ED general	0.039	-0.105	0.181	0.529	0.597
female	Ricca, 2010	female	ED general	0.480	0.401	0.552	10.499	0.000
female	rodgers, 2014	female	Combined	0.248	0.163	0.330	5.590	0.000
female	rorie, 2004	female	UWCB	0.130	0.103	0.157	9.441	0.000
female	Rukavina, 2006	female	ED general	0.260	0.087	0.418	2.915	0.004
female	Soo, 2008	female	Combined	0.291	0.207	0.370	6.601	0.000
female	vanderwal, 2004a	female	ED general	0.310	0.049	0.532	2.311	0.021
female	vanderwal, 2004b	female	ED general	0.130	-0.110	0.356	1.092	0.288
female	white, 2003a	female	UWCB	0.368	0.022	0.635	2.079	0.038
female	white, 2003b	female	UWCB	0.152	-0.227	0.491	0.781	0.435
female				0.236	0.179	0.291	7.957	0.000
male	Hadjigeorgiou, 2012	male	ED general	0.215	0.136	0.291	5.255	0.000
male	elfhag, 2005	male	Combined	0.310	0.179	0.429	4.514	0.000
male	forestier-knauss, 2012	male	Combined	0.322	0.197	0.438	4.895	0.000
male	Halliwell, 2006	male	ED general	0.150	0.028	0.267	2.409	0.016
male	kayano, 2008a	male	ED general	-0.050	-0.238	0.142	-0.508	0.612
male	kayano, 2008b	male	ED general	-0.350	-0.571	-0.082	-2.532	0.011
male	kayano, 2008c	male	ED general	-0.510	-0.663	-0.316	-4.974	0.000
male	kayano, 2008d	male	ED general	0.360	0.059	0.601	2.323	0.020
male	kayano, 2008e	male	ED general	-0.040	-0.249	0.172	-0.367	0.714
male	Kirsch, 2016	male	ED general	0.070	-0.079	0.216	0.922	0.356
male	laghi, 2015	male	Combined	0.071	-0.070	0.209	0.991	0.322
male	Ledoux, 2011a	male	Combined	0.014	-0.148	0.175	0.168	0.867
male	Ledoux, 2011b	male	Combined	0.081	-0.102	0.260	0.867	0.386
male	lombardo, 2004	male	ED general	0.320	0.258	0.379	9.612	0.000
male	Ricca, 2010	male	ED general	0.380	0.288	0.465	7.591	0.000
male				0.114	0.024	0.201	2.479	0.013
Overall				0.197	0.157	0.236	9.608	0.000

Random-effects model

Figure F8

Association between disordered eating and BMI by construct

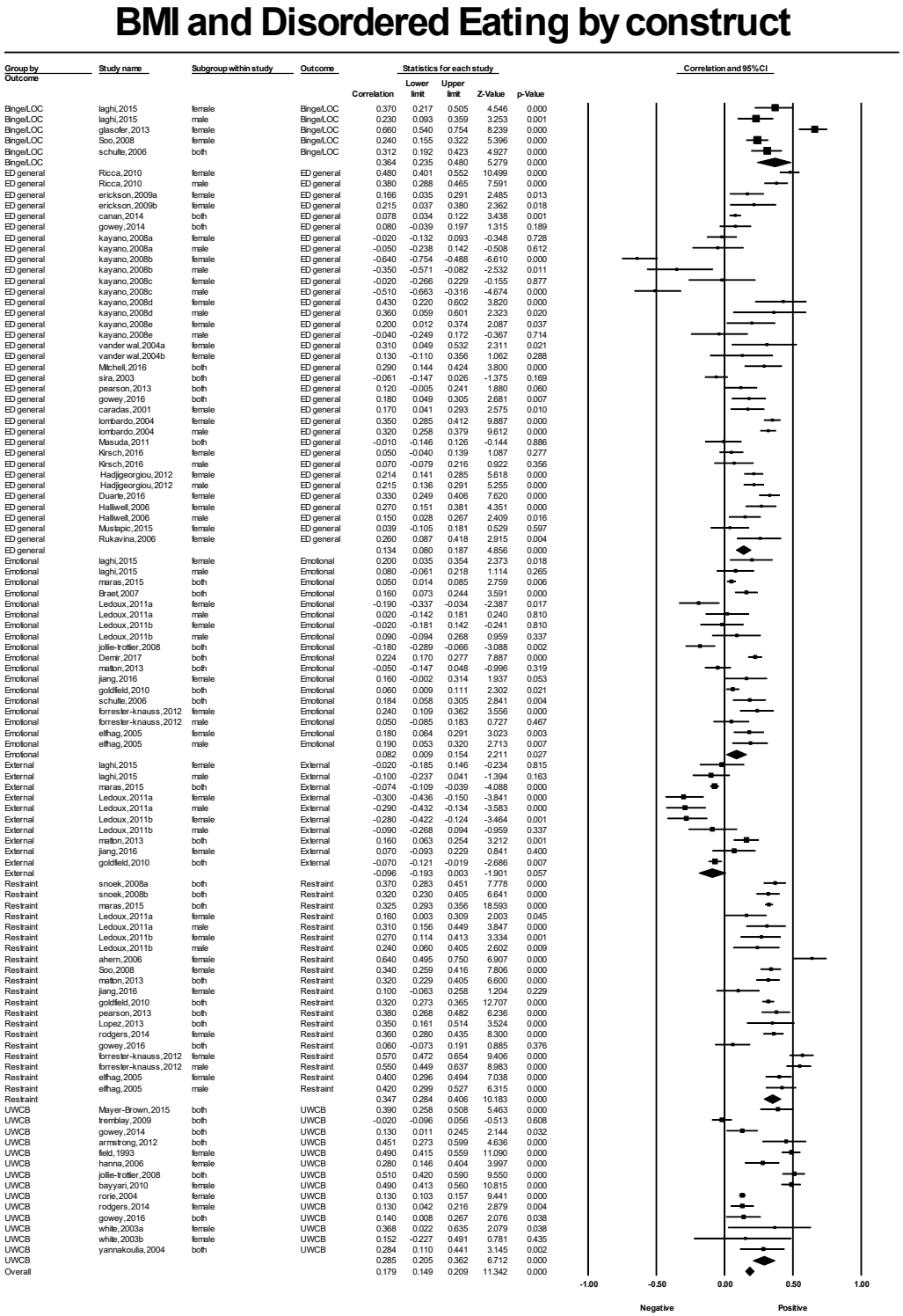


Figure F9

Association between BMI and restrained eating by sex

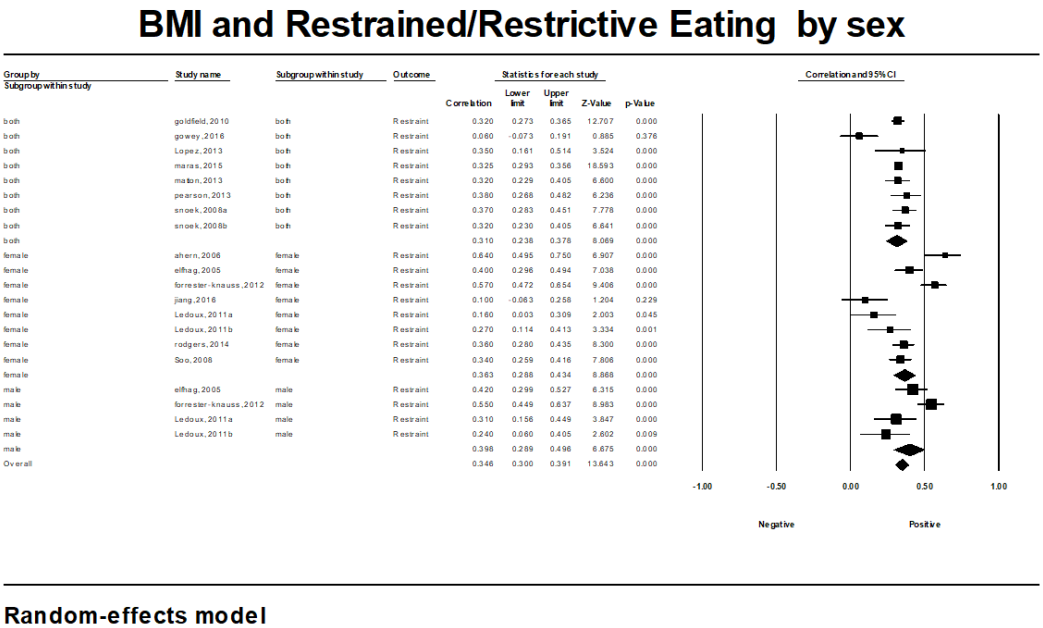
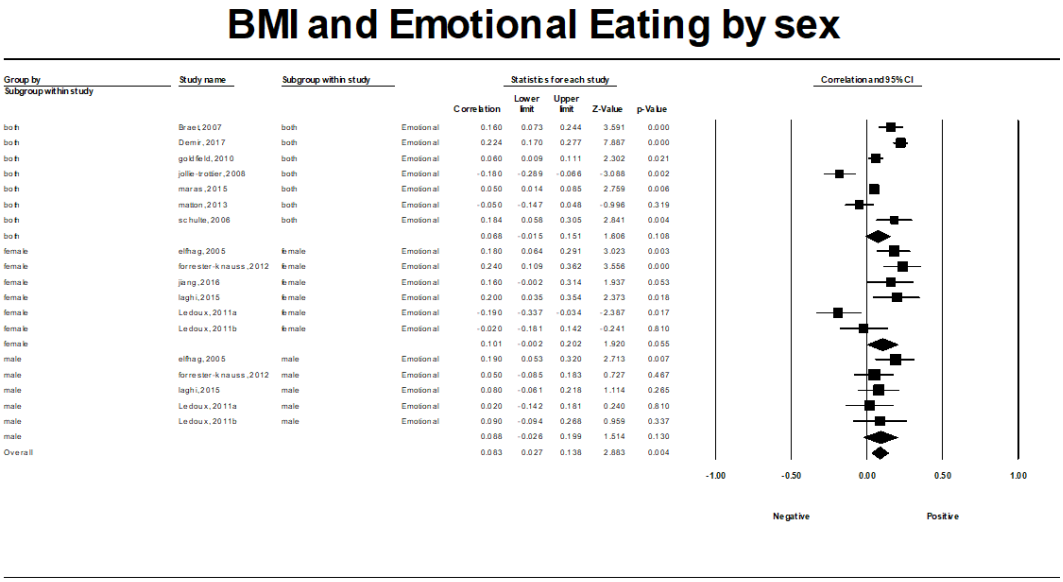


Figure F10

Association between BMI and emotional eating by sex



Appendix G – Additional Results for Study 1

Unhealthy weight control behaviours (UWCB)

Table G1 provides a summary of the meta-analysis results of the association between UWCB and BMI. There was significant heterogeneity in the magnitude of the correlation between BMI and UWCB (see Table G1). The results for the random-effects meta-analysis of the relationship between BMI and UWCB are presented.

Table G1

Summary of meta-analytic results of the association between BMI and UWCB

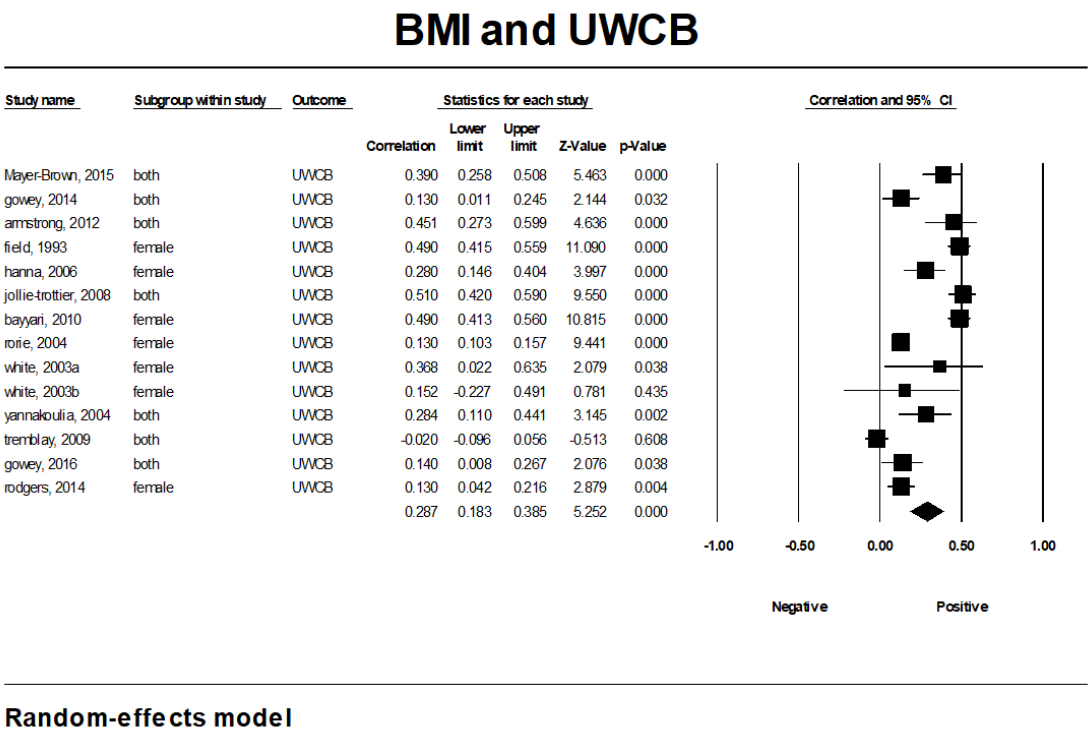
	Unhealthy weight control behaviours
Heterogeneity (*Q*; *df*=13)	211.38*
Random-effects Mean (ES)	0.29*
95% CI	0.18: 0.39

*$p < .001$

Magnitude of the relationship. UWCB were expected to be positively related to BMI. Overall, the average correlation between UWCB and BMI was 0.29, which is a positive small effect size, according to Cohen (1992). Figure G1 lists the studies included in this random-effects meta-analysis along with the distribution of their effect sizes around the summary effect size, $r = 0.29$. Heterogeneity in the effect sizes can be seen by the lack of overlap of the confidence intervals for the different studies. Effect sizes ranged from -0.02 (a negligible negative effect), to 0.51 (a moderate positive effect).

Figure G1

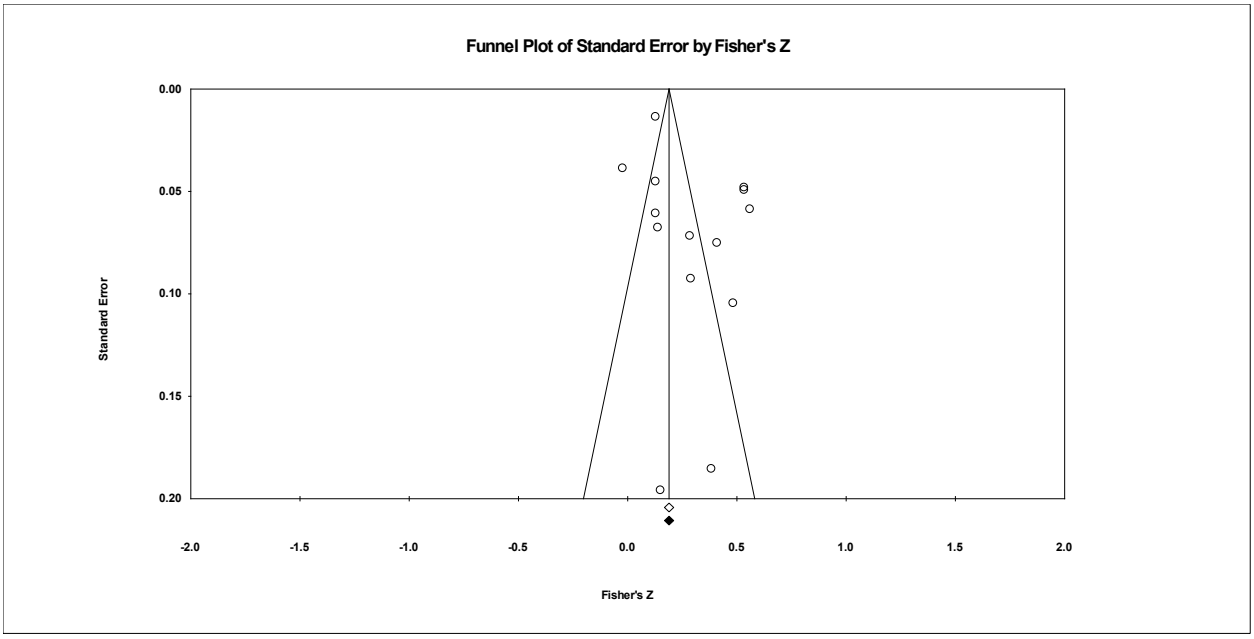
Association between UWCB and BMI



Publication bias. Visual inspection of the funnel plot indicates that there might be some studies missing from the right side of the plot. To confirm that there is asymmetry of this plot, Duval and Tweedie's trim-and-fill technique was used. Based on the results, no imputed effect sizes were added to the funnel plot (see Figure G2).

Figure G2

Funnel plot with the observed values of unhealthy weight control behaviours and BMI



Binge eating/Loss of control (LOC)

For simplicity, binge eating/loss of control will be referred to as binge eating. Table G2 provides a summary of the meta-analysis results of the association between binge eating and BMI. There was significant heterogeneity in the magnitude of the correlation between BMI and binge eating (see Table G2). The results for the random-effects meta-analysis of the relationship between BMI and binge eating are presented.

Table G2

Summary of meta-analytic results of the association between BMI and binge eating

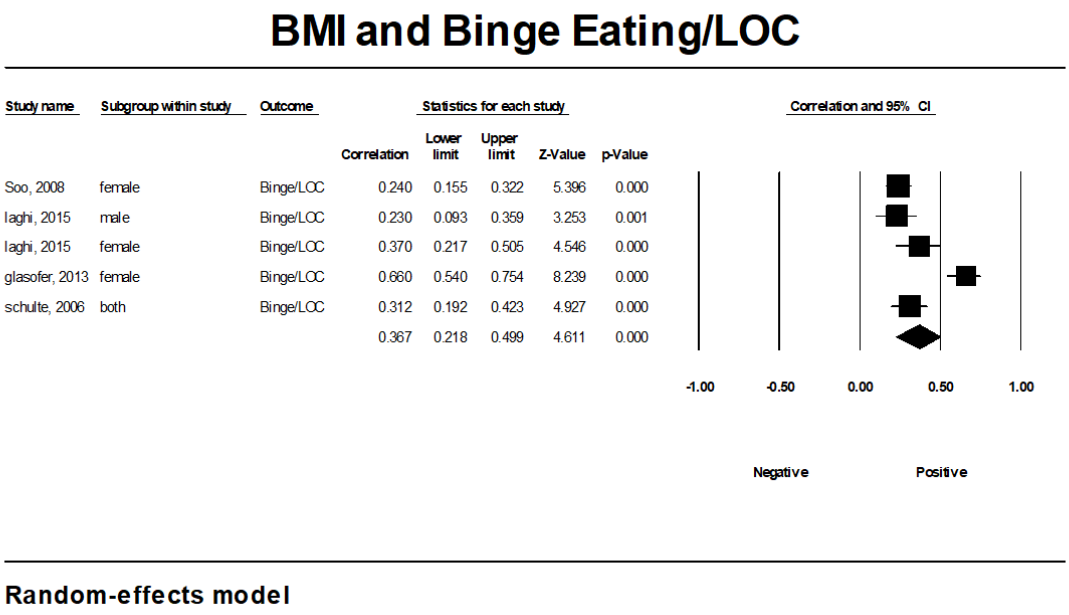
	Binge eating
Heterogeneity (*Q*; *df*=4)	28.90*
Random-effects Mean (ES)	0.37*
95% CI	0.22: 0.50

*$p < .001$

Magnitude of the relationship. Binge eating was expected to be positively related to BMI. Overall, the average correlation between binge eating and BMI was 0.37, which is a positive moderate effect size, according to Cohen (1992). Figure G3 lists the studies included in this random-effects meta-analysis along with the distribution of their effect sizes around the summary effect size, $r = 0.37$. Heterogeneity in the effect sizes can be seen by the lack of overlap of the confidence intervals for the different studies. Effect sizes ranged from 0.23 (a small effect), to 0.66 (a large effect).

Figure G3

Association between binge eating and BMI



Publication bias. Visual inspection of the funnel plot indicates that there might be some studies missing from the right side of the plot. To confirm that there is asymmetry of this plot, Duval and Tweedie's trim-and-fill technique was used. Based on the results, one imputed effect size was added to the right side of the funnel plot (see

Figure G4 & G5). The addition of this imputed study resulted in an increase in effect size between binge eating and BMI of 0.40 (see table G3).

Table G3

Results of Duval and Tweedie's trim-and-fill for the random-effects model of the association between binge eating and BMI.

	Studies Trimmed	Point Estimate	LL	UL	Q-value
Observed values		0.37	0.22	0.50	28.90
Adjusted values	1	0.40	0.26	0.53	42.83

Note: LL = lower limit; UL = upper limit

Figure G4

Funnel plot with the observed values of binge eating and BMI

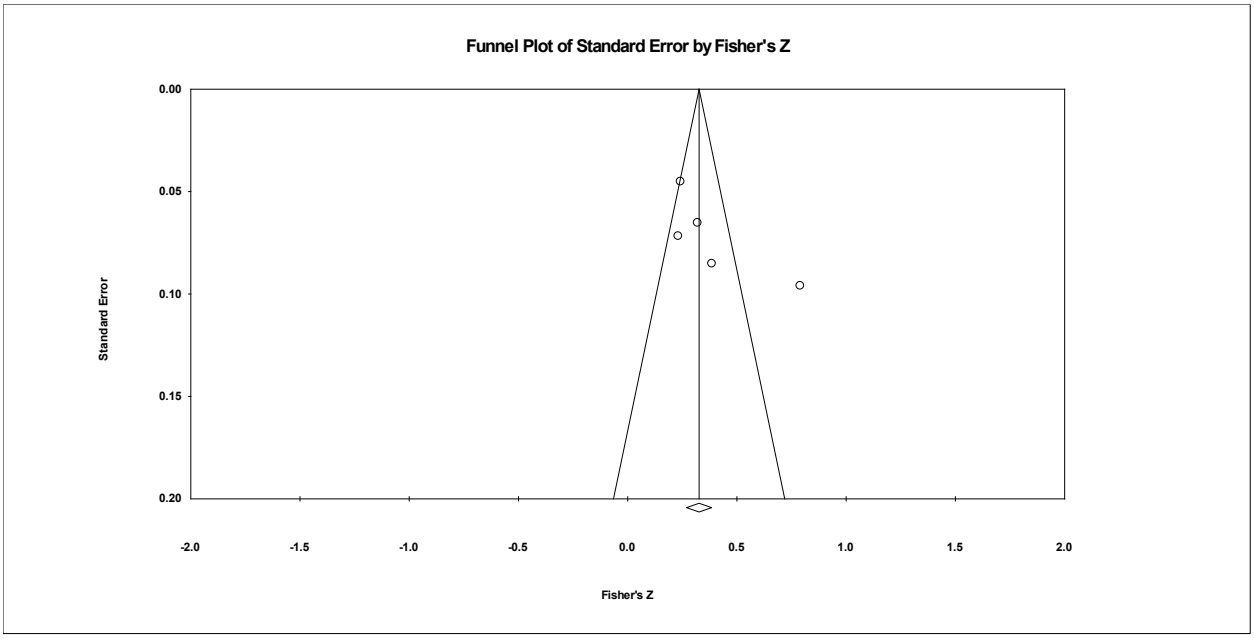
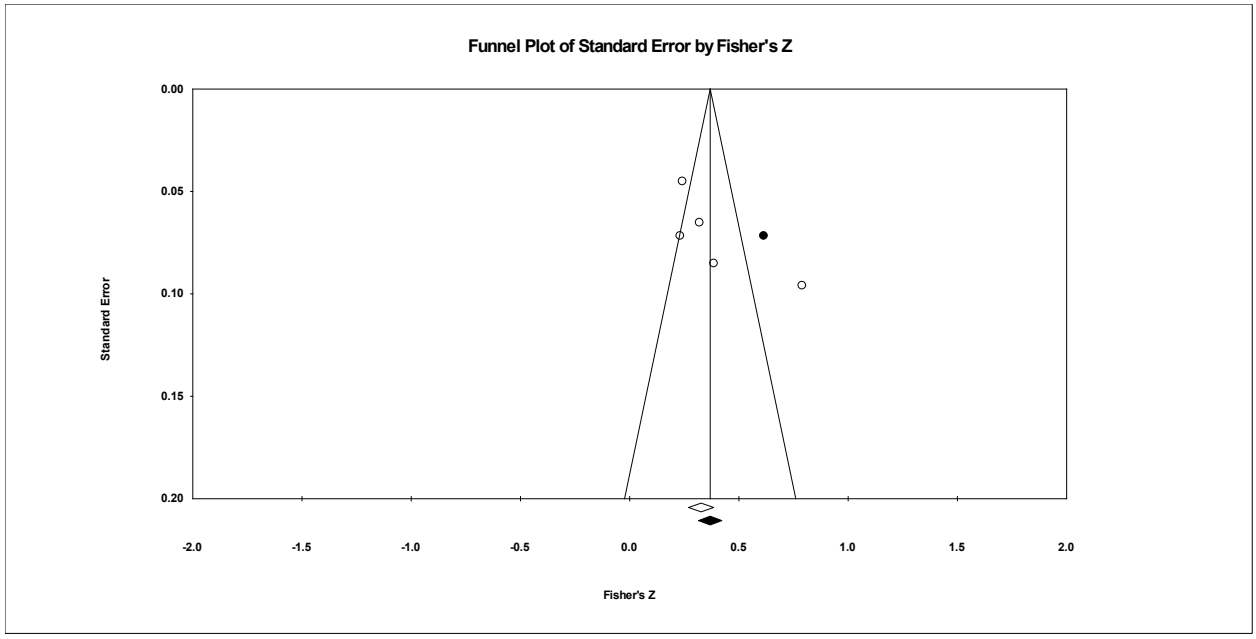


Figure G5

Funnel plot with the imputed values of binge eating and BMI



Eating disorder general

Table G4 provides a summary of the meta-analysis results of the association between general eating disorders and BMI. There was significant heterogeneity in the magnitude of the correlation between BMI and general eating disorders (see Table G4). The results for the random-effects meta-analysis of the relationship between BMI and general eating disorders are presented.

Table G4

Summary of meta-analytic results of the association between BMI and general eating disorders

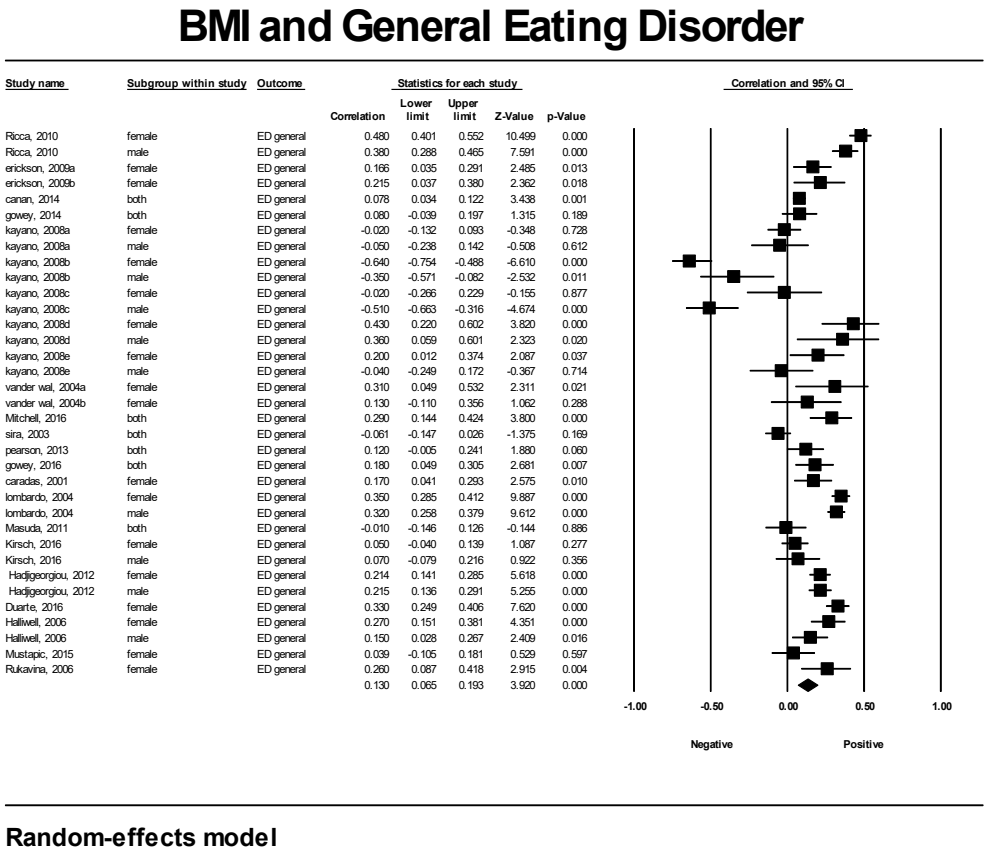
	General Eating Disorders
Heterogeneity (*Q*; *df*=34)	355.10*
Random-effects Mean (ES)	0.13*
95% CI	0.07: 0.19

*$p < .001$

Magnitude of the relationship. General eating disorders were expected to be positively related to BMI. Overall, the average correlation between general eating disorders and BMI was 0.13, which is a positive small effect size, according to Cohen (1992). Figure G6 lists the studies included in this random-effects meta-analysis along with the distribution of their effect sizes around the summary effect size, $r = 0.13$. Heterogeneity in the effect sizes can be seen by the lack of overlap of the confidence intervals for the different studies. Effect sizes ranged from -0.64 (a large negative effect), to 0.48 (a large positive effect).

Figure G6

Association between general eating disorders and BMI



Publication bias. Visual inspection of the funnel plot indicates that there might be some studies missing from the left side of the plot. To confirm that there is asymmetry of this plot, Duval and Tweedie's trim-and-fill technique was used. Based on the results, eight imputed effect sizes were added to the left side of the funnel plot (see Figure G7 & G8). The addition of these imputed studies resulted in a decrease in effect size between general eating disorder and BMI of 0.05 (see table G6).

Table G6

Results of Duval and Tweedie's trim-and-fill for the random-effects model of the association between general eating disorder and BMI.

	Studies Trimmed	Point Estimate	LL	UL	Q-value
Observed values		0.13	0.07	0.19	355.10
Adjusted values	8	0.05	-0.02	0.13	803.79

Note: LL = lower limit; UL = upper limit

Figure G7

Funnel plot with the observed values of general eating disorders and BMI

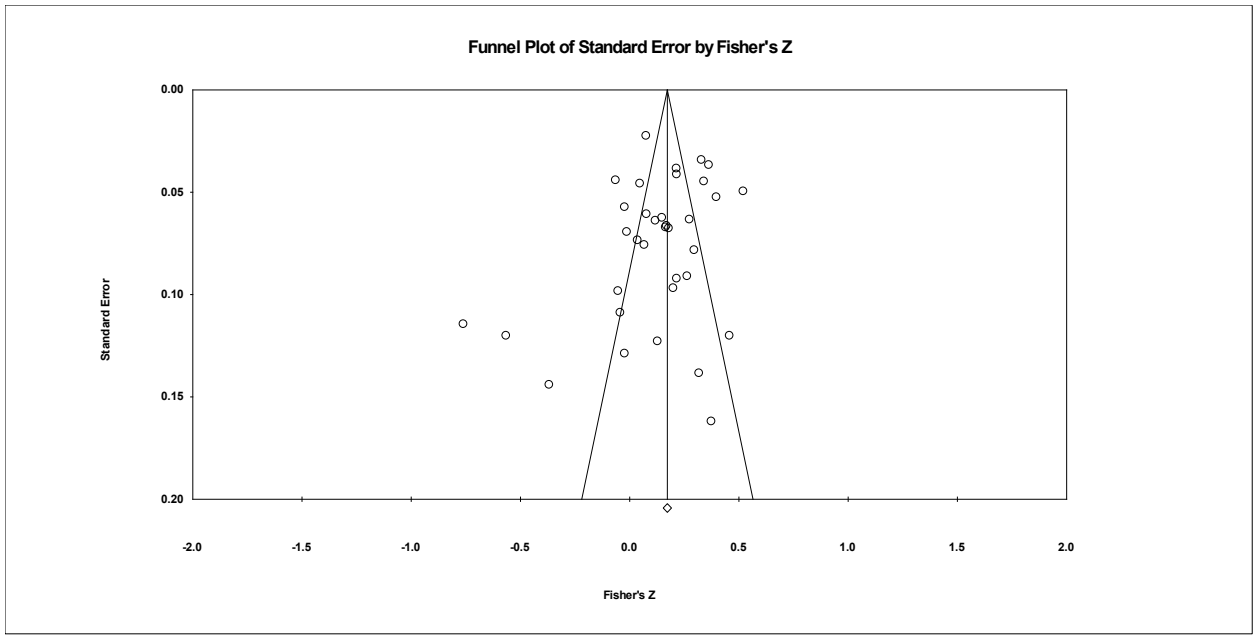
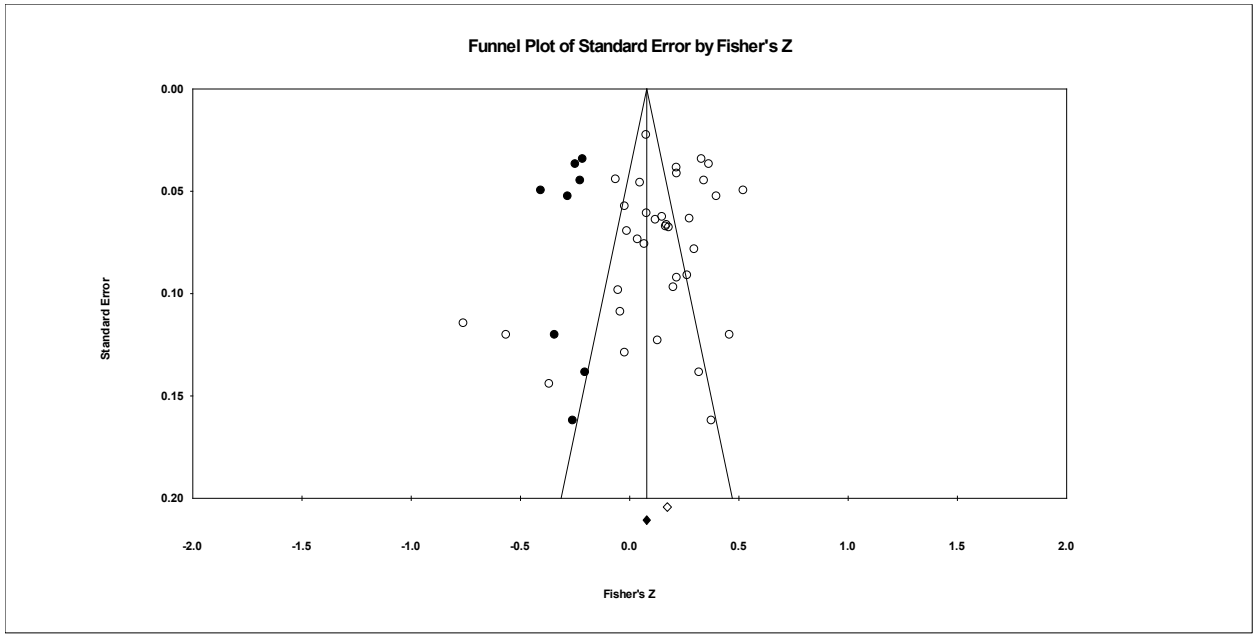


Figure G8

Funnel plot with the imputed values of general eating disorders and BMI



Subgroup analyses

While the trends in effect sizes suggest that there may be differences in effect sizes based on the sex of the sample, subgroup analyses demonstrate no significant differences between groups for each disordered eating construct (see Table G7; see Figures G9 and G10)

Table G7

Sex differences in effect size between disordered eating subgroups

		Disordered Eating	
	UWCB	ED general	Binge
Sex ($Q_{b(1)}$)	0.07	1.77	-
Both	0.27* (*k*=7)	0.10 (*k*=7)	-
Female	0.30* (*k*=7)	0.17* (*k*=18)	-
Male	-	0.08 (*k*=10)	-

Note. Too few studies in the binge eating category to test subgroups (k<5); UWCB = unhealthy weight control behaviours; ED general = general eating disorder symptoms; Binge = binge eating; Both = samples including males and females.

*p < .001.

Figure G9

Association between BMI and UWCB by sex

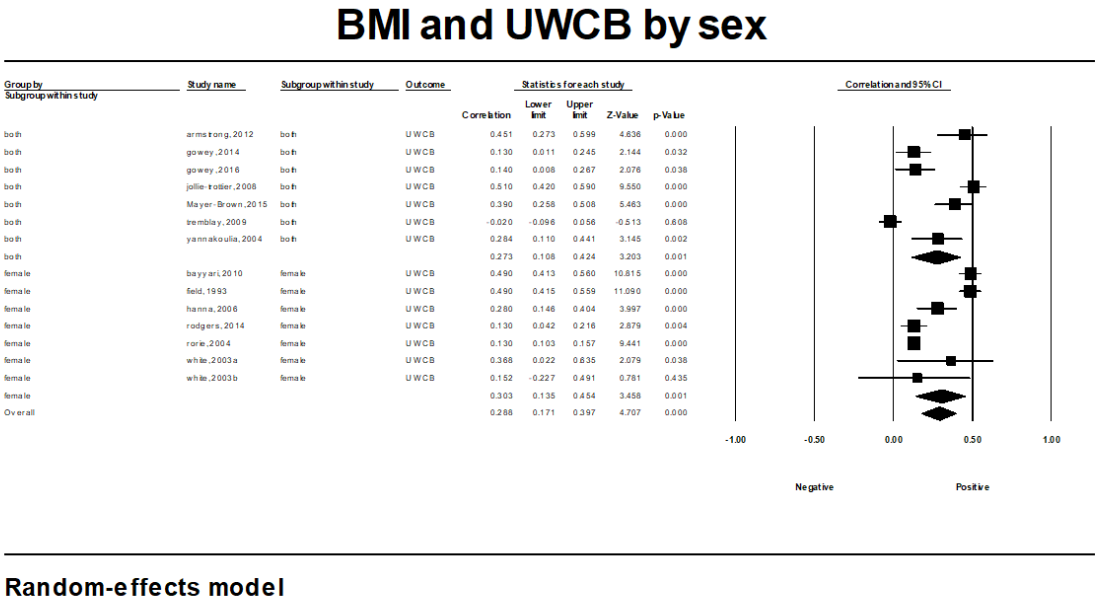
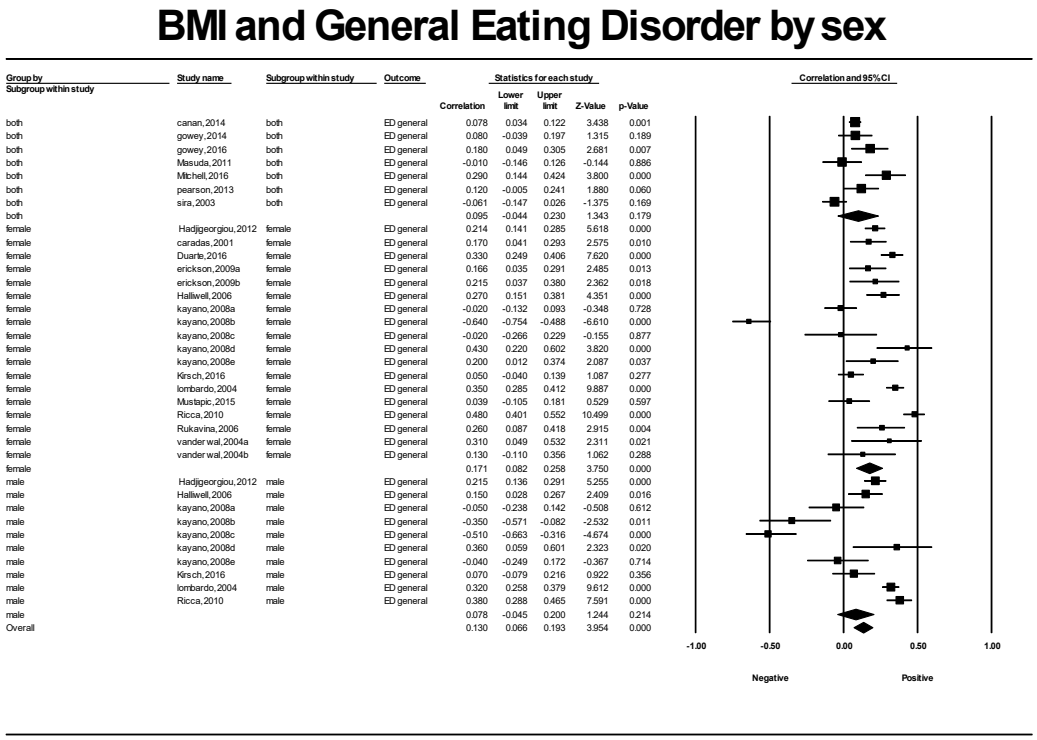


Figure G10

Association between BMI and general eating disorders by sex



Meta-regression for each disordered eating subgroup

To try to explain some of the heterogeneity between studies within each construct, meta-regression analyses were run to determine if study quality and average age of participants significantly predicted the relation between BMI and each disordered eating construct (i.e., UWCB, general eating disorders, binge eating). For UWCB ($Q(2) = 1.72$, $p = 0.424$), age ($b = 0.023$, $se = 0.018$, 95% CI [-0.012, 0.058], $p = 0.191$) and study quality ($b = -0.003$, $se = 0.029$, 95% CI [-0.059, 0.054], $p = 0.931$) were not significant predictors of the association between UWCB and BMI. The results of the meta-analysis indicated that for general eating disorders, mean age and study quality explained 10% of the between-study variance (R^2analog = 0.10, $Q(2) = 10.42$, $p = 0.006$). As the mean age

of study participants increased, the correlation between general eating disorders and BMI decreased (*b* = -0.027, *se* =0.011, 95% CI [-0.049, -0.006], *p* = 0.013). Study quality did not significantly predict the association between general eating disorders and BMI (*b* = 0.033, *se* =0.020, 95% CI [-0.007, 0.072], *p* = 0.107). Finally, results indicated that for binge eating, mean age of participants and study quality explained 95% of the between-study variance (R^2analog = 0.95, *Q*(2) = 21.37, *p* = 0.000). As study quality increased, the correlation between binge eating and BMI decreased (*b* = -0.085, *se* =0.021, 95%CI [-0.126, -0.045], *p*=0.000). Age did not significantly predict the correlation between binge eating and BMI (*b* = -0.004, *se* =0.024, 95%CI [-0.051, 0.043], *p* = 0.875).

Appendix H: Measures

BESAA

(Mendelson et al., 2001)

CHAL ID:_____ Date:_____

Package:_____

Indicate HOW OFTEN YOU AGREE with the following statements ABOUT YOURSELF by checking the appropriate box.

		Never	Seldom	Sometimes	Often	Always
1	I like what I look like in pictures.	☐	☐	☐	☐	☐
2	Other people consider me good looking.	☐	☐	☐	☐	☐
3	I'm proud of my body.	☐	☐	☐	☐	☐
4	I am preoccupied with trying to change my body weight.	☐	☐	☐	☐	☐
5	I think my appearance would help me get a job.	☐	☐	☐	☐	☐
6	I like what I see when I look in the mirror.	☐	☐	☐	☐	☐
7	There are lots of things I'd change about my looks if I could.	☐	☐	☐	☐	☐
8	I am satisfied with my weight.	☐	☐	☐	☐	☐
9	I wish I looked better.	☐	☐	☐	☐	☐
10	I really like what I weigh.	☐	☐	☐	☐	☐

11	I wish I looked like someone else.	☐	☐	☐	☐	☐
12	People my own age like my looks.	☐	☐	☐	☐	☐
13	My looks upset me.	☐	☐	☐	☐	☐
14	I'm as nice looking as most people.	☐	☐	☐	☐	☐
15	I'm pretty happy about the way I look.	☐	☐	☐	☐	☐
16	I feel I weigh the right amount for my height.	☐	☐	☐	☐	☐
17	I feel ashamed of how I look.	☐	☐	☐	☐	☐
18	Weighing myself depresses me.	☐	☐	☐	☐	☐
19	My weight makes me unhappy.	☐	☐	☐	☐	☐
20	My looks help me to get dates.	☐	☐	☐	☐	☐
21	I worry about the way I look.	☐	☐	☐	☐	☐
22	I think I have a good body.	☐	☐	☐	☐	☐
23	I'm looking as nice as I'd like to.	☐	☐	☐	☐	☐

PedsQL™

Pediatric Quality of Life Inventory

Version 4.0

CHILD REPORT (ages **8-12**)

DIRECTIONS

On the following page is a list of things that might be a problem for you. Please tell us **how much of a problem** each one has been for you during the **past ONE month** by circling:

0 if it is **never** a problem
1 if it is **almost never** a problem
2 if it is **sometimes** a problem
3 if it is **often** a problem
4 if it is **almost always** a problem

There are no right or wrong answers.
If you do not understand a question, please ask for help.

*In the past **ONE month**, how much of a **problem** has this been for you …*

ABOUT MY HEALTH AND ACTIVITIES ***(problems with…)***	**Never**	**Almost Never**	**Some-times**	**Often**	**Almost Always**
1. It is hard for me to walk more than one block	0	1	2	3	4
2. It is hard for me to run	0	1	2	3	4
3. It is hard for me to do sports activity or exercise	0	1	2	3	4
4. It is hard for me to lift something heavy	0	1	2	3	4
5. It is hard for me to take a bath or shower by myself	0	1	2	3	4
6. It is hard for me to do chores around the house	0	1	2	3	4
7. I hurt or ache	0	1	2	3	4
8. I have low energy	0	1	2	3	4

ABOUT MY FEELINGS ***(problems with…)***	**Never**	**Almost Never**	**Some-times**	**Often**	**Almost Always**
1. I feel afraid or scared	0	1	2	3	4
2. I feel sad or blue	0	1	2	3	4
3. I feel angry	0	1	2	3	4
4. I have trouble sleeping	0	1	2	3	4
5. I worry about what will happen to me	0	1	2	3	4

HOW I GET ALONG WITH OTHERS ***(problems with…)***	**Never**	**Almost Never**	**Some-times**	**Often**	**Almost Always**
1. I have trouble getting along with other kids	0	1	2	3	4
2. Other kids do not want to be my friend	0	1	2	3	4
3. Other kids tease me	0	1	2	3	4
4. I cannot do things that other kids my age can do	0	1	2	3	4
5. It is hard to keep up when I play with other kids	0	1	2	3	4

ABOUT SCHOOL ***(problems with…)***	**Never**	**Almost Never**	**Some-times**	**Often**	**Almost Always**
1. It is hard to pay attention in class	0	1	2	3	4
2. I forget things	0	1	2	3	4
3. I have trouble keeping up with my schoolwork	0	1	2	3	4
4. I miss school because of not feeling well	0	1	2	3	4
5. I miss school to go to the doctor or hospital	0	1	2	3	4

CHAL ID + Package:_____ Dutch Eating Behaviour Questionnaire Date:_____

Here are a few questions about some of your eating habits. Do your best to answer honestly.

	Never	Seldom	Sometimes	Often	Very often
1. If you have put on weight, do you eat less than you usually do?	1	2	3	4	5
2. Do you try to eat less at mealtimes than you would like to eat?	1	2	3	4	5
3. How often do you refuse food or drink offered because you are concerned about your weight?	1	2	3	4	5
4. Do you watch exactly what you eat?	1	2	3	4	5
5. Do you deliberately eat foods that are slimming?	1	2	3	4	5
6. When you have eaten too much, do you eat less than usual the following days?	1	2	3	4	5
7. Do you deliberately eat less in order not to become heavier?	1	2	3	4	5
8. How often do you try not to eat between meals because you are watching your weight?	1	2	3	4	5
9. How often in the evening do you try not to eat between meals because you are watching your weight?	1	2	3	4	5
10. Do you take into account your weight with what you eat?	1	2	3	4	5
11. Do you have the desire to eat when you are irritated?	1	2	3	4	5

	Never	Seldom	Sometimes	Often	Very often
12. Do you have a desire to eat when you have nothing to do?	1	2	3	4	5
13. Do you have a desire to eat when you are depressed or discouraged?	1	2	3	4	5
14. Do you have a desire to eat when you are feeling lonely?	1	2	3	4	5
15. Do you have a desire to eat when somebody lets you down?	1	2	3	4	5
16. Do you have a desire to eat when you are cross?	1	2	3	4	5
17. Do you have a desire to eat when you are approaching something unpleasant to happen?	1	2	3	4	5
18. Do you have a desire to eat when you are anxious, worried or tense?	1	2	3	4	5
19. Do you have a desire to eat when things are going against you or when things have gone wrong?	1	2	3	4	5
20. Do you have a desire to eat when you are frightened?	1	2	3	4	5
21. Do you have a desire to eat when you are disappointed?	1	2	3	4	5
22. Do you have a desire to eat when you are emotionally upset?	1	2	3	4	5

	Never	Seldom	Sometimes	Often	Very often
23. Do you have a desire to eat when you are bored or restless?	1	2	3	4	5
24. If food tastes good to you, do you eat more than usual?	1	2	3	4	5
25. If food smells and looks good, do you eat more than usual?	1	2	3	4	5
26. If you see or smell something delicious, do you have a desire to eat it?	1	2	3	4	5
27. If you have something delicious to eat, do you eat it straight away?	1	2	3	4	5
28. If you walk past the baker, do you have a desire to buy something delicious?	1	2	3	4	5
29. If you walk past a snack bar or a café, do you have a desire to buy something delicious?	1	2	3	4	5
30. If you see others eating, do you have a desire to eat?	1	2	3	4	5
31. Can you resist eating delicious foods?	1	2	3	4	5
32. Do you eat more than usual when you see others eating?	1	2	3	4	5
33. When preparing a meal, are you inclined to eat something?	1	2	3	4	5

Appendix I – Standardized Results for complete bidirectional model

Variable	Int BE	Int BMI	Int RE	Int Emo	Int QOL	Slope BE	Slope BMI	Slope RE	Quad RE	Slope Emo	Slope QOL
Int BE	---										
Int BMI	-0.09	---									
Int RE	-0.20	0.06	---								
Int Emo	-0.38**	0.04	0.15	---							
Int QOL	0.42**	-0.08	-0.15	-0.39**	---						
Slope BE	-0.02	0.10	-0.26	0.18	-0.14	---					
Slope BMI	0.07	-0.06	-0.07	0.05	0.02	-0.84	---				
Slope RE	-0.27	0.21	0.30	-0.02	0.01	0.36	0.43	---			
Quad RE	-0.19	-0.02	0.11	0.07	0.34	-0.34	-0.08	0.07	---		
Slope Emo	0.29	0.07	0.13	0.03	0.41	0.11	0.38	-0.90	-0.63	---	
Slope QOL	-0.24	-0.35	-0.33	0.12	-0.06	1.34	-0.27	-0.25	-0.99	-1.19	---

Note. Int =intercept; Slope = linear slope; Quad =quadratic slope; BE = Body Esteem; RE = Restrained Eating; Emo = Emotional Eating; QOL = quality of life.

**$p < .001$