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Correlates of Adherence to an Adolescent Weight Management Program: A Secondary Data Analysis

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CORRELATES OF ADHERENCE TO AN ADOLESCENT WEIGHT
MANAGEMENT PROGRAM: A SECONDARY DATA ANALYSIS

A Thesis Presented

by

Meredith Walker Hanson

to

The Faculty of the Graduate College

of

The University of Vermont

In Partial Fulfillment of the Requirements
for the Degree of Master of Science
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ABSTRACT

The aim of this study was to determine the relationship between HRQOL and adherence to an adolescent weight management program and identify variables predictive of increased adherence which are critical to motivating engagement in weight management. This study was a non-experimental, retrospective secondary analysis from aggregate data collected as part of the REWARD Teens program, a weight management program for overweight and obese adolescents. Data from 37 subjects were included in this study. Subject adherence to the program was the primary outcome variable. There was no significant relationship between baseline adolescent or parent-proxy sub-scale or total HRQOL scores with program adherence. A significant positive relationship for improved adherence was found only when change in BMI ($p=.023$), change of parent-proxy total PedsQL ($p=.014$), and change in child total PedsQL ($p=.007$) were present in the regression model. Body mass index and changes in both parent-proxy and child total HRQOL significantly affected attendance. Our findings suggest that baseline HRQOL does not affect program adherence. However, we identified a potentially novel interplay between variables predictive of program adherence. Future studies should focus on elucidating the mechanism by which these factors gained significance in the relationship with adherence when combined, perhaps as mediators or moderators, in order to identify interactions which may function as barriers or facilitators to adherence.

DEDICATION

For the countless Pediatric patients and families who continue to inspire me in my nursing career and everyday endeavors.

For my parents, role models in life and in Pediatric practice, and my greatest supporters.

For my husband and his unwavering patience, love, and support.

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CHAPTER 1: INTRODUCTION

Childhood obesity is a major and growing worldwide concern. A global survey of data bases and literature review demonstrate significant increases in obesity over the past 30 years, with recent higher rates in the developing world than in the developed world. Contributing factors are increased caloric intake (Swinburn et al., 2009; Briefal, 2004), changes in diet composition (Astrup & Brand-Miller, 2012), decreasing levels of physical activity (Hill & Peters, 2013; Swinburn, 2013), and changes in the gut microbiome (Tile & Kaser, 2011; Turnbough et al., 2006). The World Health Organization estimates that by 2020 over 60% of the global disease burden will be the result of obesity-related disorders (Ng et al., 2014). Although overall global obesity rates are higher in adults than in children, in the U.S., Brazil, China, and other countries, the obesity rates have increased at a faster rate in children than in adults (Popkin, 2006).

Childhood obesity is even greater in the developed world. In North America, where the rate has tripled over the past 30 years, 32% of North American children are now overweight and between 11.7% and 16.9% are obese (Roberts et al., 2012; Ogden et al.). In the United States, obesity rates for children 2-19 years of age more than tripled between 1980 and 2010 (Fryar et al., 2010). According to the most recent National Health and Nutrition Examination Survey (NHANES), 16.9% of 2-19 year olds in the U.S. were obese and 31.7% were overweight or obese. Estimates of childhood obesity tend to be higher in the U.S. than in other countries (Ogden et al.). Alarming, the prevalence increased with age from 12.1% among ages two-five; 18 % among ages six-11, and 18.4% among ages 12-19 years (Ogden et al.).

Obese children and teens are more likely to become obese adults (Whitaker, 1997), and obesity in adults has been strongly correlated with increased mortality and obesity-related co-morbidities such as hyperlipidemia, hypertension, heart disease, diabetes, and joint problems (Reilly, 2003). Whitaker et al. (1997) reported that after adjustment for parental obesity, the odds ratio of persistence of obesity into adulthood among obese 15-17 year-olds was 17.5 times higher compared to non-obese subjects, and that 79% of obese 10-14 year-olds with at least one obese parent remained obese in adulthood. Among older children, obesity was found to be an increasingly important predictor of future adult obesity regardless of parental obesity. This indicates that adolescence is a critical period for increased risk for obesity persisting into adulthood.

Obesity is detrimental to both the physical and psychosocial health of youth in a critical developmental stage (Reilly & Kelly, 2010). Childhood obesity can reduce life expectancy by two-five years (Ludwig, 2007). Obese children are more likely to have type II diabetes, formerly an affliction that arose almost exclusively in adulthood. Further obese children are at increased risk for orthopedic and sleep problems, cardiovascular disease, and metabolic syndrome (Reilly & Kelly, 2010). In 2010, 3.8% of disability-adjusted life-years (DALYS) were attributable to obesity (Ng et al., 2014).

An analysis of data conducted by the National Center for Education Statistics from a nationally representative sample of 21, 260 U.S. children found that fewer than one in five children, identified as obese or overweight in kindergarten, were normal weight by the fifth grade (Hernandez et al., 2015). Further, Cunningham et al. (2014) reported that children at the 50th percentile of body mass index (BMI) at age five had a

6% probability of being obese at age 14 while 72% of children who were at the 99th percentile at age five were still obese by the end of 8th grade. Collectively, this suggests that children who were obese from a young age remained obese into adolescence and adulthood, in contrast to normal weight children of whom few became obese adults. This persistent obesity predicts a heavy burden of cardiovascular, endocrine, and psychological disease.

Negative obesity-related consequences are not confined to physical co-morbidities, disability, and increased mortality, but also include psychosocial and economic effects which persist into adulthood. Gortmaker et al. (1993) conducted a retrospective study (n=10,039) of 16-24 year old women who had been overweight in adolescence, evaluating social and economic characteristics eight years later. In young adulthood, these women reported fewer years of school, lower household incomes, higher rates of poverty (10% higher), and were less likely to be married compared with normal-weight women with other chronic conditions. Negative obesity-related consequences are not confined to physical co-morbidities, disability and increased mortality, but also include psychosocial and economic effects. Findings were independent of baseline intelligence aptitude and socio-economic status (SES). Men overweight at baseline were 11% less likely to be married. This suggests that early overweight status may have a proportionately greater long-term impact on quality of life.

The physical, emotional, and social consequences of the childhood obesity epidemic places a heavy burden on global medical and economic resources, both during childhood and with the onset of obesity related chronic illness and disability afflicting

them as obese adults. The economic burden includes medical and hospitalization costs and economic losses attributed to school and work absenteeism due to illness and disability (Finkelstein et al., 2009; Finkelstein et al., 2014). An economic analysis found that individuals with obesity have 30% greater medical costs than individuals with normal-weight (Withrow & Alter, 2011).

Significant psychosocial impairments such as depression, anxiety, low self-image or self-esteem have been correlated with childhood obesity (Hillman, 2010; Kubzansky, 2012; Lawler, 2011). These comorbidities are pronounced in adolescence, a period of rapid developmental change and transition. During this stage, self-image and social, emotional, and school functioning are vulnerable, especially for obese adolescents (Hillman, 2010; Morrison, 2015; Pruder & Munsch, 2010; Puhl, 2012). Psychosocial correlates in obesity are associated with lower quality of life (Jansen, 2013; Ottava, 2012, Ul-Haq, 2013) and are consistently lower in overweight and obese children (Schwimmer et al., 2003; Wake et al., 2002; Swallen, 2005). Quality of life (QOL) has been shown to correlate inversely with the degree of adiposity (Ul-Haq, 2012; Jansen, 2013; Keating, 2011; Williams, 2005). Poor social-emotional functioning has been associated with unhealthy increasing BMI trajectory over time (Chang, 2013; Cameron, 2012). While it has been well documented that obesity is associated with lower health-related quality of life (HRQOL) (Kolodziejczyk, 2015), causality has often been difficult to establish related to methodological limitations (Cameron, 2012). Research has focused generally on HRQOL as a consequence of obesity, but a bi-directional or cyclical relationship has been suggested (Jansen, 2013; Pruder & Munsch, 2010). While increasing obesity has

been correlated with deteriorating physical and emotional HRQOL over five years in adults, low HRQOL was also demonstrated to predict weight gain over that time (Cameron, 2012). Well-being, measured by various HRQOL instruments has been identified as integral to motivating engagement in weight management for children and adolescents (Hoyt, 2012; Pitrou, 2010). Impaired social relationships are shown to be affected by adolescent obesity (Rancout & Prinstein, 2010; Puhl, 2012), and such impairment has been shown to persist into young adulthood (Loth, 2011). Thus, it is essential to develop evidence-based interventions to enhance engagement in weight management programs and to optimize psychosocial well-being.

Evidence-based interventions for obesity treatment including nutrition, exercise, and individualized motivational counseling may positively impact not only obesity-related biometrics, physiologic measures, and weight outcomes, but also psychosocial and quality of life (Bock, 2014; Sacher, 2010). Moreover, improvements in quality of life have been shown even in the absence of BMI or other biometric marker changes, further emphasizing the importance of including psychosocial and quality of life measures as primary outcomes (Skelton, 2011).

Attrition rates in intervention programs have been high, ranging from 4- 83%, with a mean of 41% (Dhaliwal, 2014). Adherence (i.e. participation rates) has been an impediment to successful completion of weight loss interventions (Skelton & Beech 2011). Adherence has been shown to correlate with successful biometric and psychosocial outcomes in obesity interventions (Rice, 2008; Patrick, 2006; Dhaliwal, 2014). Therefore, it is essential to investigate and better understand the factors that

influence adherence. Health-related quality of life, which broadly encompasses physical, social, and emotional well-being and school functioning, may help to identify individual and family factors that predict optimal intervention participation and adherence thus optimizing weight status and other fitness measures.

Theoretical Framework

The theoretical framework used in this study was Albert Bandura's Social Cognitive Theory (SCT) (1986). Bandura states that belief in one's personal efficacy plays a seminal role in personal change and "is the foundation of human motivation and action" (*Ibid*, p. 144). Social cognitive theory posits that beliefs related to one's self-efficacy determine the strength of commitment to health-related goals and impact the duration of perseverance despite difficulty, failures, and resilience to difficulties (Bandura, 1998). Bandura defines the core theoretical determinants as knowledge of health risks and benefits of a given health problem, perceived self-efficacy that one can exercise control over one's health habits, outcome expectations, individually-determined health goals, and social impediments and facilitators to change (Bandura, 2004). In addition to individual factors, SCT includes social and structural determinants of health, such as parental and family support and peer and social relationships, a multi-faceted structure impacting the "acquisition of competencies that can profoundly affect physical and emotional well-being as well as the self-regulation of health habits" (Bandura, 1998, p.2).

Purpose

The purpose of this study was to determine the relationship between HRQOL and adherence to a weight management program and to identify psychosocial factors which may affect adherence in a multidisciplinary, behaviorally- and family-based adolescent obesity intervention. Secondly, the purpose was to compare profiles of adolescents who completed the program to those who did not.

Research Question

To investigate the study hypotheses, the primary research questions were as follows: (1) How does HRQOL correlate with adherence in the REWARD Teens adolescent weight management program

The specific aims for this study were: (1) Determine the relationship between adolescent HRQOL and adherence. (2) Determine the relationship between HRQOL as perceived by parent and adherence. (3) To compare parent and child perceptions of child's HRQOL.

Hypothesis

Stemming from SCT, the *a priori* study hypothesis was that adolescents with low HRQOL were less likely to adhere to a weight management program. Conversely, we expected that adolescents with greater HRQOL would have better adherence, attendance, and outcomes at completion of the 12-week program.

Significance

Poor rates of adherence to evidence-based adolescent obesity interventions are major barriers to alleviating adolescent obesity and its physical and psychosocial health

consequences (Dhaliwal et al., 2014). Health-related quality of life, a measure of social, physical, and emotional functioning, has been shown to be lower in obese children and adolescents than leaner children and adolescents. Identifying psychosocial factors that have previously been found to predict poor adherence to treatment may permit targeted individual assessments that could be instituted prior to obesity program enrollment. Awareness of known predictors of poor adherence prior to enrollment might improve adherence, improve psychosocial and biometric outcomes, and inform the design of future evidence-based adolescent weight management programs.

Increased knowledge of psychosocial factors related to poor adherence to a weight management program could aid advanced practice registered nurses (APRNs) in identifying barriers to successful weight management for their adolescent patients. Further, this allows the APRN to highlight areas which might require specific psychosocial interventions. Successful management to reduce overweight and obesity is critical to preventing chronic illnesses. Successful interventions are important for containing escalating obesity-related health-care costs. Due to the expense and time of treatment programs, it is important to identify participants who have a greater likelihood of successful outcomes.

Identifying adolescent psychosocial correlates of treatment adherence and optimal participant profiles may assist clinicians and researchers to improve adherence and outcomes by individually tailoring weight management strategies by including psychosocial interventions. Parental assessment of the child's HRQOL may add to identification of psychosocial factors that affect adherence and success. In addition,

parental perception of the severity of the psychosocial aspects of obesity on their child could positively impact their willingness to ensure child participation.

Implications for Advanced Practice Nursing

The increasing prevalence of obesity and associated sequelae of cardiovascular, orthopedic, and psychosocial co-morbidities requires team-based, multi-disciplinary prevention and management strategies of chronic disease in both primary care and specialty settings. Advance practice registered nurses, including licensed Nurse Practitioners (NPs), are uniquely prepared to manage this challenge. Their education and training emphasize a perspective on “the whole patient” whose health and wellness is impacted by family, community, workplace, culture and spirituality.

The NP core competencies are guidelines and essential core behaviors by which the NP’s education prepares the individual for full independent clinical competence. The ability to critically analyze data and evidence allow improvement of nursing practice. Translating research and other forms of knowledge to enhance patient outcomes, and developing new practice approaches based on the integration of theory, research, and practice knowledge, are all critical to the APRN’s success in effectively caring for obese and overweight children and adolescents in the future (NONPF, 2012).

The competencies of utilizing the best known evidence to improve the quality of clinical practice, as well as generating knowledge from practice to guide and improve patient outcomes, are integral skills to direct management of chronic disease in primary care. Findings from this study are important in the identification of psychosocial factors as both predictors, barriers to remediation, and/or prevention of obesity and outcomes of

overweight and obesity. Leadership in translating such new knowledge into clinical settings, whether primary care, specialty or weight management programs, requires the core competency of practice inquiry.

The independent practice competency is essential to understanding quality of life issues and the effective management of deficits which act as a barrier to the patient's successful engagement in behavioral change interventions. In doing so, the APRN should "provide the full spectrum of health care services to include health promotion, disease prevention, health protection, anticipatory guidance, counseling, and disease management" (NONPF, 2012, p. 4). Negotiating a mutually acceptable plan of care with respect, collaboration and empathy, is critical to engaging the obese adolescent and family in sustainable change.

CHAPTER 2: LITERATURE REVIEW

Obesity is a complex disease, with many aspects and contributing factors, including socio-economic status, gender, and ethnicity. The purpose of this review is to explore the current state of knowledge concerning psychosocial correlates of obesity, both as primary outcome measures, but also as possible predictors of positive outcomes and other fitness measures. What follows is a review of literature of psychosocial correlates of obesity and outcomes and design of interventions including psychosocial and health-related quality of life measures. The impact of psychosocial factors, including parental motivation for change and parental assessment of adolescent's commitment to change on adherence and the association of adherence with achieving positive outcomes are also reviewed. The 2009 Cochrane review (Oude, 2009) advocated investigation of psychosocial determinants for behavior change leading to improved weight status.

Research prior to 2003 has used single-outcome measures to assess the combined impact of obesity on children's psychosocial and physical well-being, self-esteem, glucose intolerance, and/or changes in BMI. Subsequently, researchers have attempted to evaluate the impact of elevated BMI or adiposity more broadly using comprehensive measures of physical, emotional, social, school or occupational functioning, in other words, overall quality of life. Various measures have been utilized to evaluate essential elements of obesity interventions to assess psychosocial factors reflected in quality of life related to illness. Health-related quality of life (HRQOL) is defined by the World Health Organization (WHO, 1948) as a subset of quality of life directly related to an individual's health, including physical, mental, and social well-being.

Positive outcomes in measures of adiposity, psychosocial parameters, and quality of life have been demonstrated in many studies, but poor retention and participation rates, and adherence to behavior change has continued to present a major barrier to achieving long-term benefits for many obese adolescents (Dhaliwal et al., 2014). Therefore, it is critical to better understand the psychosocial correlates associated with adherence to support individuals at risk of poor adherence. While environmental, family, and demographic variables are important, this study examined individual psychosocial and functional characteristics correlated with adherence and obesity.

Psychological Correlates of Obesity

Obese children and adolescents are at increased risk of developing significant impairments in QOL and psychosocial functioning. A systematic review examined the relationship between obesity and obesity-related behaviors with neurocognitive functioning in youth (Liang et al., 2014). They found an inverse correlation between executive functioning, attention, visual-spatial performance, and motor skills. Authors cautioned that directionality of the relationship was unclear (Liang et al., 2014). These cognitive impairments may impact school and social functioning.

Pruder & Munsch (2010) identified eleven studies that found clear associations between obesity and psychological distress, including internalizing problems (i.e. anxiety, depression, isolation, and withdrawal) and externalizing behaviors (i.e. hyperactivity, problematic conduct, peer conflict, low self-esteem, and impaired social functioning). Pitrou et al. (2010) conducted a study of 1,030 French 6-11 year-olds of whom were overweight (17.3%) or obese (3.3%). They reported that children whose

parents reported poor peer relationships were twice as likely (adjusted OR 2.06) as those with reported normal peer relationships to be overweight. Anxiety was the only self-reported psychosocial symptom found to be associated. This study supports the psychosocial burden of obesity and overweight, even in young children and adolescents.

Quality of Life

Ul-Haq et al. (2013) conducted a meta-analysis between 2003-2011 to evaluate the association BMI and HRQOL among children and adolescents less than 20 years of age. Included were 11 studies from the U.S., Australia, Scotland, the Netherlands, Israel, and England. Only three of these studies analyzed focused solely on the adolescent age group, making the results less generalizable to adolescents. The authors found that both physical and psychosocial health-related quality of life were significantly reduced in obese children and adolescents. Quality of life decreased as the degree of overweight increased and HRQOL in all domains was significantly reduced in obese children ($p < 0.001$). Weaker associations in clinically overweight children ($p = .012$ summary scores; $p = .084$ psychosocial scores) were found as well. Total parental scores of children's HRQOL showed greater reduction ($p < .001$). Overall HRQOL, as well as physical and psychosocial domains, were directly related to degree of overweight, with smaller reductions in overweight than in obese children. Inferences in causality are limited as the majority of studies were cross-sectional. Thus, one cannot interpret to what extent reduced HRQOL preceded or was subsequent to obesity onset. In an adult study Ul-Haq et al. (2012) found that quality of life was significantly reduced only in morbidly obese adults (BMI > 40 kg/m²), but not in overweight adults (BMI 25-29). The authors

deduced that the psychosocial consequences of increased BMI may be greater in children than in adults, supporting the urgency to further examine the relationship of HRQOL both as a primary outcome of obesity interventions and as a possible barrier to adherence to such interventions.

A secondary data analysis (Ottova et al, 2012) evaluated 13,041 children and adolescents aged 8-18 years from ten European countries participating in the KIDSCREEN Health Interview Survey. Overweight children (14.2 %) in all countries had lower HRQOL scores than normal-weight children, with the most significant determinant being physical well-being (effect size 0.12) and self-perception (effect size 0.021), independent of age or gender. Poland and the United Kingdom (U.K.) demonstrated smaller effects of social acceptance and bullying domains in overweight children (effect size 0.006). Compared to children (age 8-11 years), adolescents (age 12-18 years) showed higher rates of overweight (51.1% vs. 48.9%, $p \leq 0.001$) and lower HRQOL on physical well-being and self-perception, but slightly higher HRQOL on social acceptance and bullying, demonstrating the importance of studying these age groups as separate cohorts. A positive correlation between HRQOL and depressive symptoms in obese adolescents and the importance of measuring body fat rather than weight or BMI alone, as it was the only consistent correlate of HRQOL. Countries used different sampling techniques, including telephone sampling, school surveys and in-school administration, and school surveys followed by mail, resulting in a wide range of response rates (24.2-91.2%) and possibly skewing the data. Parent-reported heights and weights were used to calculate BMIs and to classify children as overweight, presenting a

significant limitation of potential bias (Goodman et al., 2000). Strengths included use of internationally accepted BMI cut-points norms, use of a standardized, validated measure of HRQOL, and a large multi-country community- and school-based population database, all of which facilitated making more accurate comparisons and results generalizable to European children and adolescents over age eight.

Keating et al. (2011) conducted a cross-sectional analysis by of 2,890 adolescents in Pacific Obesity Prevention Project communities in Australia. Overweight and obese adolescents (mean age 14.6) reported significantly lower HRQOL in physical and social functioning, while obese adolescents reported additional low emotional functioning. In terms of age and sex, girls and adolescents younger than 15 reported more significant reductions in HRQOL with excess weight.

A retrospective analysis of the population-based Longitudinal Study of Australian Children (LSAC, N=3,898) identified an inverse relationship between overweight and HRQOL was evident by 6-7 years of age (Jansen et al., 2013). Significant associations between poorer HRQOL, physical, psychosocial health, and obesity developed by 8-9 years, and was even greater at 9-10 years. Cumulative impacts were evident. The duration a child was overweight between ages 4 and 11 predicted progressively poor scores for both physical and psycho-social health at 10-11 years of age (p values ≤ 0.001). Children with poor physical health trended toward higher mean BMI at age 10-11 years, but the association was small and inconsistent over time. The relationship between physical poor health and psychosocial function was even weaker. This appears to indicate that

overweight and obesity in childhood may lead to worsening HRQOL rather than the reverse.

Schwimmer et al. (2003) evaluated HRQOL in 106 obese children and adolescents ages 5-18 years (mean 12.1 years) in both healthy children and in children with cancer on chemotherapy. Obese children and adolescents were more likely to have lower HRQOL than healthy children and adolescents (OR=5.5) and were similar to children and adolescents with cancer (OR =1.3). The obese children and adolescents reported significantly lower HRQOL ($P<0.001$) compared with healthy children and adolescents. A longitudinal cohort study (Williams et al., 2005) in Australia of grade-school children found that both perceived parent and child HRQOL decreased with increasing child weight ($p\leq.001$). Decreases in physical and social functioning were significant ($p\leq.001$) but decreases in emotional and school by weight were not significant. Effects were smaller than those reported in Schwimmer's (2003). Taken together, these studies demonstrated that impaired HRQOL, manifested in both physical and psychosocial functioning, was significant in childhood and adolescent obesity.

Psychological Correlates of Obesity

Morrison et al. (2015) conducted a cross-sectional study to explore individual, family, and biological determinants of depressive symptoms and HRQOL in a large Canadian population of obese 8-17 year olds ($n=242$) seeking treatment. Measures of depression and HRQOL, BMI, and adiposity using dual x-ray absorptiometry (DXA) were measured. Thirty-six percent of children were classified as depressed. No differences in age, sex, pubertal development or family history of depression were found.

Multivariate regression analysis identified higher household income as a predictor of lower rates of depression [OR 0.79; CI 95%]. Adiposity, but not BMI, was weakly associated with increased risk of depression [OR 1.08 (CI 95%)]. All domain scores in HRQOL were lower in the depressed group compared to the non-depressed group ($p \leq 0.01$). The HRQOL was related to age, but not pubertal status, and inversely related to degree of adiposity measured by either BMI or percent body fat. The degree of obesity was also inversely related to each domain of HRQOL except to school functioning. Physical and emotional function domains were related only to degree of obesity. Percent body fat was the most consistent mediator of HRQOL, and was the only variable related to the total HRQOL and the physical functioning. For every 1% increase in body fat, the total PedsQL score declined by .06, the physical functioning score by 0.82, and the social domain score by 1.22. No correlates of the emotional functioning domain were found. Obese adolescents had a higher rate of depression, 36.4%, compared to general adolescent population at rates of 5-8%. This is at the upper end of the range (4-33%) reported in previous studies (Van et al., 2009). These findings suggest that broader HRQOL measures of psychological functioning, may cast a wider net that captures psycho-social functional deficits. Thus, it is important, to have more specific measures such as depression screening instruments. Limitations of the study were a cross-sectional design, which prevents inferences of causality. The sample was an obesity treatment-seeking group from Canada that may limit generalizability and may not reflect the population as a whole.

Hillman et al. (2010) evaluated the association between anxiety and depressive symptoms and obesity in 198 healthy female adolescents recruited from an outpatient teen clinic and surrounding community of a large Midwestern city, at age 11, 13, 15, and 17 years. Approximately 39% of the teens were overweight or obese. Adiposity was determined by DXA and BMI. The authors found a positive association of trait anxiety and depressive symptoms with both BMI and adiposity independent of age, race, and Tanner stage. Thus, symptoms of anxiety and depression were associated with adiposity among female adolescents, connecting psychological distress with adiposity. For each increase of one standard deviation for anxiety, there was an associated 0.78 unit increase in BMI and 1.03 unit increase in percentage body fat. This study suggests that as BMI increases, so do anxiety and depression. Therefore, these characteristics should be appropriately assessed and addressed. Since this study was cross-sectional, further investigation is needed to determine cause and effect and directional influences. Significant positive associations were also found between depressive symptoms and BMI ($p=.002$), percentage body fat ($p=.004$), and fat distribution ($p=.03$). Together with Morrison et al. (2015) these findings suggest that clinical anxiety and depression symptoms exist in both community and treatment samples of obese adolescents. Limitations included the absence of males and the small number of non-White participants, limiting its generalizability. It would be important to know if QOL measures adequately identify anxiety because of its association with adolescent obesity.

To evaluate the relationship between psychological distress and BMI trajectory, Kubzansky et al. (2012) used growth mixture modeling in a sample of 1,528 subjects to

create classes of BMI trajectories over a four-year period. Subjects were enrolled between 2001 and 2005 from a longitudinal school-based study of cardio-metabolic risk in Greater Cincinnati. Psychological distress (i.e. depression and anxiety) and BMI were measured every four years. At baseline, Blacks reported both greater depressive symptoms and had greater BMI. Females reported higher levels of distress and post-pubertal female subjects had greater BMI. Anxiety and depressive symptoms overall were similar to those reported in other populations of children and adolescents (Cujpers et al., 2008; Sawyer et al., 2009). Subjects did not cross BMI cut points annually over four years. Despite the prospective longitudinal design, it was unclear if levels of anxiety and depression at baseline predicted increasing levels of obesity over time. Thus, the study was not able to establish whether psychological distress led to greater weight gain. However, this study suggests that obese Black children and obese females are more likely to have more psychological distress related to their weight status.

Chang et al. (2013) conducted a secondary data analysis to examine weight status stability and change across adolescence of a U.S. nationally representative sample of children (n=6,220; 66% White non-Hispanic; 16% Hispanic; 8% African-American; average age 11.23 years). Methods included standardized teacher and child self-report of social and emotional development. Social emotional functioning at fifth grade significantly predicted weight status stability or change by the eighth grade. Children with internalizing behaviors (anxiety and depression), poor peer relations, and/or higher levels of anger on teacher report were more likely to move into a higher BMI percentile. However, a potential confounder was as children move through adolescence their

behaviors became less observable to parents as they spend more time outside the home and view of parents. This study further supports previous findings that the quality of a child's social and emotional functioning in school may be a significant factor in weight trajectory during adolescence.

Higher rates of social rejection, stigmatization, and weight victimization, have been frequently reported by obese youth. Rancourt & Prinstein (2010) reported impaired social peer relationships of obese children in a longitudinal study of 576 North Carolina 10-14 year olds. The authors used sociometric peer nomination scores derived from peer responses to assess likability and popularity. They found lower BMI to be associated with increased likeability ($p < .01$) and higher BMI to be associated with an increase in negative weight-related cognitions ($p < .01$).

Puhl et al. (2012) examined ways that overweight adolescents cope with weight-based victimization at school. Of an initial sample of 1,555 Connecticut students, 394 students reported weight-based victimization (mean age 16.4%; 56% female; 84% white). Of the 394 adolescents, 50% reported feelings of sadness, depression, anger or fear and feeling worse about themselves. Maladaptive coping mechanisms were associated with increased overweight and included skipping gym, increasing food intake, and binge eating. Collectively, these studies support that overweight/obesity is associated with increased psychological distress and main impair HRQOL.

Mediators of BMI and HRQOL: Body Image and Self-Esteem

Previous studies have demonstrated psychosocial distress and poor emotional well-being not only with overweight, but also with shape and weight. Kolodziejczyk et al

(2015) evaluated the relationship between individual and environmental variables on the relationship between BMI and HRQOL in two interventions aimed at reducing weight in overweight and obese adolescents at risk of DM type 2. The sample (n=205) was mostly female, age 12-16, and Latino with low SES (household income below \$25,000). The first arm used a computer-supported intervention in primary care settings. The second arm used the Intervention for Youth at Risk for Diabetes (PACE-iDP) protocol. Their analysis found that both body image and to a lesser degree self-esteem explained the inverse relationship between BMI and HRQOL, while neither depression nor environmental factors proved to be mediators. In contrast, Stern et al. (2007) found that depression, as well as low self-esteem, was associated with lower HRQOL in obese adolescents, and that self-esteem mediated the relationship between weight-related teasing and HRQOL relationship between weight-related teasing and HRQOL. Ali et al. (2010) found that self-perception of weight was more strongly associated with depression than actual weight. They concluded that obesity was not a predictor of depression, but that depression was related to impaired HRQOL. This suggests that self-image and self-perception, though related to HRQOL, may provide more specific targets for remediation.

Gouveia et al. (2014) investigated psychosocial correlates in obese adolescents. They reported body image dissatisfaction was a mediator between obesity and HRQOL. Weight status was inversely associated with body image dissatisfaction at 8-18 years. Obese adolescents, age 10-12 years, appeared more vulnerable for the development of body image dissatisfaction. Obesity was inversely related to health-related quality of life

in children less than 8 years. Higher levels of internalizing and externalizing behaviors were seen in these obese adolescents than were found in non-obese populations. Higher body image dissatisfaction was not associated with these characteristics. The authors conclude that inclusion of body image-related assessments and intervention components in studies of obese pre-adolescents and adolescents are needed. Also important are studies that investigate psychosocial correlates and determinants of obesity to further the understanding of the contribution of body image dissatisfaction to lower HRQOL seen in obese children. Tailoring specific therapy for body image dissatisfaction may be integral to affective treatment.

The impact of adolescent overweight and negative emotional well-being has been shown to persist into early adulthood. Long-term implications for quality of life and psychological sequelae have been established. The literature suggest an interplay between psychological distress and obesity. Psychological distress may foster weight gain, and obesity may produce psychosocial problems for affected children. In summary, early detection of psychological factors that contribute to developing and maintaining overweight and obesity is essential to improve prevention and intervention efforts. Data has been contradictory due to heterogeneous samples, study design, and inconsistent quantitative measures used. Controlled, longitudinal, widely representative studies using standardized definitions for childhood obesity and consistency in standardized psychological measurement instruments would enhance generalizability and comparability of the outcomes.

Interventions for Obesity Treatment

Overweight and obesity is frequently correlated with psychological distress and lower quality of life than in non-obese peers. Effectiveness of intervention programs should be measured not only by anthropomorphic measures, but also by improvements in HRQOL and other psychological comorbidities such as depression and anxiety.

Expert and Consensus Statements Regarding Components of Effective Interventions

An expert panel (Barlow et al., 2007) was convened to evaluate recommendations for components of evidence-based pediatric obesity management. The panel recommended that interventions should be family-based and multi-dimensional and should promote healthy lifestyle changes through education, motivational counseling, and family involvement. The authors suggested that with older youth the focus should be increasingly on the adolescent, but that parents need to continue to provide a supportive environment and mutual commitment to these goals. The authors acknowledged that parental involvement should be progressively less for older youth and that there should be an increasing focus on the adolescent, with parents providing a supportive home environment.

Hoare et al. (2015) conducted a systematic review of mental health and well-being outcomes in community-based obesity prevention interventions for adolescents. Only seven of 46 eligible studies reviewed targeted adolescents ages 10-19 and incorporated validated measures of mental health and wellness measures. They found that validated measures of mental health and well-being could improve identification of mechanisms that influence adolescent weight-related outcomes, as well as ensuring the

interventions are not causing harm to adolescents' mental health. Consequently, the authors strongly recommended that the mental health be a primary outcome measure for obesity intervention programs.

Evidence-based recommendations for family-centered, multi-disciplinary weight management interventions should last at least one year (Barlow et al., 2007). Research has attempted to define the optimal components and setting for child and adolescent weight loss interventions that would result in continued participation, retention of obese adolescents, and lead to improved measures of adiposity and fitness (Whitlock, 2010). School-based settings have been identified as the most common and convenient to implement physical activity programs (Neumark-Sztainer et al., 2003). Exercise intervention in school-based programs has been found to decrease fat mass and improve measures of fitness (Carrel, 2005).

Lifestyle Interventions Impact Physiologic Measures

Ho et al. (2012) conducted a meta-analysis and systematic review of 13 randomized controlled trials (RCTs). The authors examined the impact of lifestyle interventions incorporating a dietary component on both weight change and cardio-metabolic risks in overweight and obese adolescents ≤ 18 years of age. The study was conducted in hospital, community, and primary care settings (Ho et al., 2012). Treatment arms were a nutrition component to no treatment, usual care, or written education material. Fourteen were conducted in hospital settings; followed by community, school and primary care settings (n=6 each). Thirteen included children, seven included adolescents, and others included both age cohorts. Sample size ranged from 16-258

children (median 72). Intervention length was three months to one year for studies comparing intervention to usual care. Lifestyle interventions were positively correlated with significant BMI reduction compared to both controls (BMI-1.25 kg/m²; 95% [CI], -.158- -1.03) and to usual care (-1.30 kg/m² immediate change; 0.92 kg/m² post-treatment sustained to one year follow-up; 95% CI, -1.58- -1.03). Significant improvements in blood lipids, insulin and blood pressure were observed up to one year from baseline. Studies were conducted between 1974 and 2010, potentially confounding variables such as changing knowledge, parental, teacher and physician attitudes, and food environment. Intervention components varied widely. In addition, there were no psychosocial baseline or outcome measures reported. The meta-analysis supported that lifestyle interventions produced significant BMI reductions compared to no treatment controls as well as significant improvement in biometric measures associated with cardiovascular risk factors at 1 year.

Programs Which Measured Both Biometric and Psychosocial Impacts

Family-based behavioral weight control programs have been shown to produce significant improvements in adiposity measures (Bock, 2014; Sacher, 2010; Wilfey et al., 2007). Children and families who participated in family-and behaviorally based obesity interventions were more likely to experience long-term improvements in degree of overweight compared to children provided calisthenics programs and diet (Epstein, 1994). This improvement was attributed to family and behavioral skills-related factors, such as self-monitoring skills, meals eaten at home, and family and friend support for lifestyle changes (Epstein, 1994). The involvement of the family in child obesity

interventions that include behavioral components is essential to successful biometric outcomes.

Multi-disciplinary, family-centered, outpatient lifestyle interventions may improve HRQOL as well as biometrics in obese children and adolescents. A Canadian (Bock et al., 2014) one-year family-centered, multidisciplinary lifestyle intervention for obese 8-17 year olds, based on social cognitive theory, used fifteen 90-minute sessions conducted by a dietician, exercise specialist, and social worker. Objective measures of body composition and HRQOL were assessed at baseline, three and 12 months. Primary outcome measures were change in BMI. Secondary outcome measures were HRQOL and body composition. Baseline HRQOL was impaired for both physical functioning (4.5 +/- 16.5 and 63.7 +/- 19.4, CI 95%) and emotional functioning (69 +/- 14.9 and 64 +/- 18.3) on parent and child report. At 12-month follow up, both parent-reported assessments of child physical (11.3 +/- 19.2 95%, 95% CI 4.7 to 17.9) and emotional (7.7 +/- 14.3, 95% CI 95% 2.4-13) functioning HRQOL and the children's self-reported physical (5.3 +/- 17.1, 95% CI 0.5-11.1) and emotional (7.9 +/- 14.3, 95% CI 3.2=12.7) functioning significantly improved. This provides further evidence that obese children have impaired physical and emotional functioning and interventions that include nutritional, behavioral counseling, and exercise can significantly improve HRQOL and lean body mass. Bock et al. (2014) concluded that such interventions can be effective in improving both physical and emotional quality of life and biometric outcomes if participants sustained attendance for 12 months. They further cautioned that obese participants lower physical and emotional functioning at baseline might impair self-efficacy affecting adherence to

weight management programs. What remains unknown is the possible association between degree of impairment at baseline and program retention.

A randomized controlled trial (Sacher et al., 2010) evaluated outcomes of the Mind, Exercise, Nutrition, Do-it (MEND) Program, a family-based community intervention for obese children (n=116). The program consisted of 18 sessions over nine weeks, including behavior change counseling, nutritional education, and physical activity, followed by free family passes to a community swimming pool for a subsequent 12 weeks. The control group was “wait-listed”, but received the same intervention six months later. Waist circumference and BMI both improved with a weak trend toward reduced fat mass in the intervention group. Weak Global self-esteem significantly increased at six and twelve months ($p=.007$) at twelve-month follow-up ($P=0.04$, 95% CI), suggesting that weight loss programs including components of behavioral health can improve not only degree of obesity, but also psychosocial well-being in children and adolescents.

Lloyd-Richardson et al. (2012) conducted a 24-month RCT of a comprehensive lifestyle intervention for 118 obese adolescents (68% female), age 13-16 years. Both groups received the same 16-week cognitive behavioral treatment and, in addition, were randomized to either aerobic exercise or peer-based adventure therapy modeled on Upward Bound. Body mass index, self-efficacy, and self-perception were measured at baseline and at 12 and 24 months post-randomization. Both groups showed significant reductions in BMI at all data points ($p < .001$), with no significant differences between those measurement times. Improved self-concept, including physical appearance, social

acceptance, and global self-concept, was reported in both groups. Only improvements in physical appearance-related self-concept were sustained at 24 months in all groups. Maintenance of weight loss was significant at all time points ($p < 0.001$). The authors postulated that other aspects of the weight-loss program, such as exercise and peer-based adventure activity, may beneficially impact self-concept independently of weight loss. Therefore, evaluation of the efficacy of weight-loss programs should ideally include measures of self-efficacy and self-concept.

Nguyen et al. (2012) evaluated the efficacy of an adolescent weight management intervention (the Loozit program) in which 151 overweight or obese 13-16 year olds participated. Participants were recruited from a community health center and children's hospital setting. The two-phase intervention consisted of a low-intensity weight management program intended to be sustainable in community settings. The first two months of the program consisted of seven adolescent and parent weekly sessions focused on lifestyle modification. In phase two, adolescents attended "booster" sessions once every three months for 24 months and were randomized to the standard Loozit weight loss maintenance program or to Additional Therapeutic Contact (ATC) with electronic reminder messages. At twelve months significant reductions in mean BMI (-0.09, 95% CI -0.12 to -0.06), weight-to-height ratios, and blood lipids were found in the Loozit participants. Significant self-reported psychosocial improvements, including global self-worth ($p < 0.001$), subjective social status ($p < 0.001$), body shape satisfaction ($p < 0.001$) and mental health inventory scores ($p = 0.01$) were also reported. Additional therapeutic contact had no significant effect on the outcome measures at twelve months. Strengths

included a 75% retention rate, the use of an intent-to-treat analysis, and an RTC design for the ATC component. A follow up study (Nguyen, 2013) reported Loozit 24 -month outcomes similar to the twelve-month outcomes. Reductions in BMI, blood lipids, consumption of high-fat foods, and improved psychosocial outcomes were observed despite poor long-term attendance in booster group sessions. As at 12 months, ATC demonstrated no added benefit.

DeBar et al. (2012) conducted a primary-care based multi-component, lifestyle intervention specifically designed for overweight adolescent females. In this single-blinded RCT (N=208; mean age 14.1, age range 12-17 years) the control group received “usual care”, including written information about evidence-based weight management for youth and adults, a parent’s guide for lifestyle changes and local resources for weight management and healthy activities. Adolescents met with their primary care providers (PCPs) in a large health maintenance organization at baseline to encourage health lifestyle changes. The intervention group received 16 group sessions for teens weekly for the first three months bi-weekly and thereafter, yoga, dance video games, and PlayStations, 12 group sessions for parents, and health education and psycho-educational materials. The decrease in BMI over time was significantly greater for intervention participants compared to usual care participants (p=0.01). Intervention groups reported greater body satisfaction (p=0.03), less internalization of social norms regarding female attractiveness (p=0.02). In contrast to many community-conducted weight management trials that rely on self-referral, all teens and families whose health records indicated eligibility (BMI $\geq 90^{\text{th}}$ percentile) for this study were contacted for recruitment. Unlike

previously cited studies, this study focused on only adolescent girls and also on teen autonomy in managing weight, rather than adopting a family-centric approach.

Adherence

Adherence is defined as “the extent to which a person’s behavior—taking medication, following a diet, and/or executing lifestyle changes, corresponds with agreed recommendations from a healthcare provider” (Haynes, 2002). Many researchers instead measure attrition, defined as a reduction in numbers or drop-out rate, which implies non-adherence. The mode of measuring adherence, which include participation rates, completion rates, and attrition rates varies throughout the literature, making study comparison challenging.

Greater attendance and completion of obesity interventions appears to affect successful outcomes in adults (Wadden & Letizia, 1992; Fontaine & Cheskin, 1997; Honas et al., 2003). LeBlanc et al. (2011) reported in a systematic review of adult obesity treatment programs that behaviorally based treatment resulted in statistically significant 3-kg greater weight loss in intervention than control participants after 12-18 months, with more treatment sessions associated with greater loss. Trials were rated as poor quality and excluded if attrition was $\geq 40\%$. Clinically significant weight loss is defined as 5% and recommended as the outcome goal for interventions (USFDA, 2007). Participants lost an average of 4% of baseline weight. However, interventions with more sessions showed more weight loss. Patients receiving 12-26 intervention sessions generally lost 4-7 kg (6% of baseline weight) compared with little or no weight loss in control groups.

Attendance at more intervention sessions was associated with improved weight. This supports that adherence can be essential to successful weight outcomes (Raynor, 2014).

Several studies have demonstrated that better participation rates and duration of participation predict improved outcomes. Rice et al. (2008) reported that youth who adhered to a weight management program of 24 weeks over 12 months had greater increases in body mass than those who did not adhere, confirming the importance of retention and degree of participation in intervention programs. Patrick et al. (2006) found that females with drop-out or lower adherence were less likely to meet dietary and behavioral goals for females. Males with lower adherence had decreased physical activity goals.

In 2011 a National Institute of Health (NIH) work-group convened to address novel strategies to improve long-term outcomes for weight loss maintenance in obesity treatment in adults. Poor adherence to behavioral treatments was identified as a major barrier that needed to be addressed. Research in adults supports maximizing motivation (West et al., 2011) and establishing self-regulatory skill sets prior to entering weight loss programs (Kiernan et al., 2013). Although not particularly addressed in children, this suggests that motivational interviewing and developing self-regulatory skills prior to entering weight loss programs may enhance participation of interventions in children.

In an Italian study (Michilini, 2014), 146 adults were assigned one of two groups, a prescriptive diet or a novel brief group cognitive behavioral treatment (CBT) plus prescriptive diet for six months. Although there was a higher attrition rate in the CBT group than in the prescriptive diet group (39.7% vs. 24.7%), differences between groups

in dropout rates in regard to sex, age, BMI, history of weight cycling, education, work or marriage were not statistically significant ($P=0.127$) at 6 months. Regardless of weight loss, the most important factor predicting drop-out was high level of personal stress. This study suggests that personal stress in adults may be a deterrent to treatment adherence. The higher attrition rate in the CBT group might be due to the additional time and personal commitment required, making it more difficult to attend. Thus, child adherence to multi-disciplinary weight management programs may be negatively related to parental stress. Adult studies may serve as a guide to examining risks for attrition in children or adolescents when parents are involved.

Little literature exists about what factors might specifically influence child adherence to weight management programs, but several studies have examined adherence to treatment in other chronic diseases. A cross-sectional study was designed to evaluate depression, HRQOL, and adherence in adolescent renal transplant patients. Parents who rated their children's quality of life as problematic on several dimensions, including depressive symptoms, reported 75% non-adherence to treatment (Dobbels et al., 2010). Parents perceived their adolescent's HRQOL as worse than did parents of healthy controls. Interestingly, the adolescents' self-report of quality of life was similar to healthy controls, except for their perception of school-related physical and psychological functioning. Prasad et al. (2002) found that adherence to exercise regimens in pediatric cystic fibrosis patients was increased by improved knowledge of the disease. Exercise contributed to an enhanced sense of competency, as an increased support of the family and health care team. Quality of life factors were not assessed (Prasad et al., 2002). In a

study of adolescents with Type I Diabetes, low baseline HRQOL predicted less frequent blood glucose monitoring at 6 months and poorer glycemic control at one year (Hilliard, 2013), demonstrating that HRQOL was related to future health behaviors and outcomes. Tiggelman (2015) supported the importance of higher baseline HRQOL that predicted increased medication adherence at follow-up in a study of adolescents with asthma. The study found lower HRQOL in adolescent liver transplant patients on Tacrolimus therapy was found to be significantly related to lower HRQOL by patient and parent-proxy reports. None of these studies examined causal impact of HRQOL and health outcomes.

Factors impacting adherence to treatment in chronic illness may not accurately reflect the factors impacting adherence in childhood obesity. However, it appears that a sense of perceived self-competence and HRQOL may be important when identifying those at risk of non-adherence and sub-optimal outcomes in long term management for chronic conditions. Efforts to improve adherence to obesity treatment requires further research specific to overweight and obese adolescents.

Assuring optimal adherence is important in weight-management interventions. Higher levels of attendance have been shown to result in positive weight-related outcomes (Raynor et al., 2014). Children and families who adhered to family-and behaviorally based weight management programs were more likely to experience long-term benefits such as long-term weight-maintenance and psychosocial improvements (Epstein, 1994).

High attrition rates from pediatric weight management programs have been found to be a barrier to successful obesity treatment (Skelton & Beech, 2011). In a 2014 review

conducted by Dhaliwal (2014) attrition rates ranged from 4-83% (mean 41%). Skelton et al. (2011) conducted a review of contributors to attrition in pediatric weight management programs. They found attrition rates of 37% to 73%, with one European study reporting 91% attrition at two-year follow-up. Importantly, there was lack of a consistent definition of adherence. Adherence was defined as a percentage of intervention sessions attended, while others used an absolute number of sessions or completion of data collection at the end of the intervention period. The lack of consistent definitions poses challenges in comparing studies related to program adherence.

Ottava et al. (2012) studied a European sample of 13,041 children and adolescents aged 8-18 years to analyze the impact of overweight on HRQOL. Of the overweight children, 46.6% were in the low socio-economic status (SES) category ($p \leq 0.001$) and were more likely to have low parental education category ($p \leq 0.001$) than their normal weight counterparts. Age, gender, socio-economic status, and parental education levels were significantly associated with overweight child weight status and HRQOL domains.

Although demographic factors, such as age, gender, ethnicity, parental socioeconomic and educational status, and family income are well documented barriers to adherence in childhood weight management programs, psychosocial factors also impact adherence. Unlike Michilini (2014), who found no relationship between attrition and social or demographic factors in adults, DeNiet (2011) found that social determinants such as ethnicity and family structure did predict attrition rates in children in weight management programs. A sample of overweight or obese children, 8-14 years ($N=248$) and their families participated in a one-year, family-based, multidisciplinary group

cognitive behavioral lifestyle intervention between 1996-2007. The outcome measures were improved BMI through weight maintenance during growth, adopting a healthy lifestyle, and creating a positive self-image. Competencies (i.e. activities, social, and school) and emotional (i.e. anxiety, mood, and somatic complaints) and behavioral problems (i.e. aggressive or antisocial/delinquent behavior) were assessed by parent report. Competency scores in the study families and the overall Dutch population were comparable. Ethnic minority status and older age of the child predicted attrition between 0-3 months. Having a non-White mother, participating in fewer activities, and having higher delinquency scores predicted attrition at 3-9 months. Higher BMI, fewer social problems, lack of regular breakfast, and families without flexible rules were predictive of attrition at 9-12 months. The authors hypothesized that lack of family stability and flexible disciplinary styles might be related to attrition. Other potential reasons cited for attrition might reflect family disorganization, the need for children's help at home, lack of transportation, living in unsafe neighborhoods, or lower SES.

Higher baseline child and parent BMI (Jelalian, 2008; Braet, 2006), older child age, self-reported depressive symptoms, poor self-concept (Zeller, 2004), and ethnic minority status (Williams, 2010) have been reported as predictors of child and adolescent attrition from weight intervention programs. Distance from treatment site had been inconsistently reported as a significant predictor (Zeller, 2004). A randomized trial by Jensen et al. (2012) evaluated demographic and psychosocial predictors of attendance in a family-based behavioral weight management program (n=93 families). Overweight or obese children and adolescents aged 7-17 years (mean age 11.59 years) were referred to

an outpatient clinical setting by school nurses and physicians as well as by advertisements. Families were randomly assigned to one of two arms. Arm one was a 10-week behavioral-based group intervention for children and families (*Positively Fit*). Arm two was a three-session individually delivered nutrition education intervention to children. The treatment arm involved parents and children attending separate meetings for all components of the treatment and adolescents were seen separately from younger children. The control group was assigned to sessions with a licensed dietician for shorter 36-minute sessions with both child and parent present. Controls were required to read the *Trim Kids* manual prior, and had three subsequent meetings over the course of 10 weeks. Distance from the participant's home to the intervention site, lower gross family income, and frequency of youth's self-reported depressive symptoms were associated with lower percent attendance ($p < 0.05$). Increased attendance predicted improved BMI ($p = 0.02$). However, there was no significant association between BMI and attendance in the control arm of the study. The authors suggest that their use of percent-of-sessions-attended as a continuous variable provided increased power to detect significant associations and provided a more nuanced examination of the data. The study had several limitations. Child participants were morbidly obese (mean BMI percentile = 98.18%), and there was a relatively homogenous sample of mostly non-Hispanic White participants. Variables such as self-efficacy, appetite, or family stress were not measured possibly affecting depressive symptoms and attrition. However, it appears that depressive symptoms may be a barrier to successful weight management adherence. Children may benefit from evaluation of depressive symptoms before beginning a weight management intervention.

Other factors that could impact both attendance and depressive symptoms should be examined as well as tailored treatments to identify comorbid factors such as parenting style or family stress and emotional environment.

A 2014 RCT (Bean et al., 2014) examined adherence among 99 obese adolescents (mean age 13.8 +/- 1.8 years). Each group participated in Teaching Encouragement Exercise Nutrition Support (TEENS), which includes biweekly dietitian and behavioral support visits and supervised physical activity three times per week. The intervention group received additional brief motivational interviewing (MI) sessions at weeks one and ten. Compared to controls, the MI sample had greater three-month overall adherence (89.2% vs. 81.0%, $p=0.040$) and adherence to dietician (91.3% vs. 84%; $p=0.046$). Behavioral support visits ($p= 0.041$). At 6 months overall adherence was (84.4% vs. 76.2%, $p=0.026$) and to behavioral support visits (87.5% vs. 78.8% $p=0.011$) remained significant at 6 months, suggesting the benefit of brief motivational interviewing (MI). Although the sample was 73% African-American and 74% female, MI enhanced adherence and should be considered in future adolescent obesity interventions to enhance adherence.

In an integrative review of the literature, Dhaliwal (2014) analyzed studies of obesity interventions that incorporated lifestyle and behavioral components for children at birth through 18 years of age. Attrition rates, as well as predictors of and reasons for attrition were primary outcome variables. The authors divided the studies into those with either *a priori* or *post-hoc* plans for attrition analysis. Post-hoc studies identified child-related demographic factors (i.e. age, sex, weight status, ethnicity) and child co-morbid

factors. The a priori studies found child-predictors of decreased adherence to be older age, higher baseline BMI, ethnicity, depression and poor self-concept. Family and environmental factors identified as predictive of poor adherence included inadequate insurance, low SES, parent obesity-related medical conditions, and problematic home environment. Six studies looked at the link between adherence and psycho-social, behavioral, and lifestyle factors. Mixed results were found regarding the relationship of anxiety and depression to attrition. Braet (2006) found that anxiety predicted poorer adherence, but two other studies found neither externalizing nor internalizing (i.e. depression/anxiety) symptom levels to be predictive of adherence.

Using a clinical database, Skelton et al. (2011) studied a multidisciplinary clinic for obese children age 2-18 years with a weight-related co-morbidity (n=133, mean age 12 years, mean BMI 38 kg/m², 52% female and 50% Medicaid recipients.) Consistent with other studies, the authors identified a 32% attrition rate. They reported that children with higher BMI, commercial insurance, average school performance, and major weight-related co-morbidity were less likely to remain in the program, while those in the attrition group were more likely to be older and to have lower BMI and poorer school performance. There was no fee for participation so cost was not considered as an attrition variable. The most common parent-reported reasons for attrition were the child's lack of readiness for lifestyle change, lack of weight improvement, desire to leave the program, and the program not meeting parent or child expectations. Study findings suggest that measurements of parent and child readiness for change or parent's perception of child's readiness would be important pre-intervention data. It could be hypothesized that

individualized MI prior to study intervention may be an effective strategy to determine and optimize readiness. It also suggests the need to counsel parents about beneficial outcomes of weight-management programs such as improved self-concept, quality of life, fitness, adiposity, and body satisfaction other than weight loss alone.

Dolinsky et al. (2012) studied predictors of attrition from a clinical pediatric weight management program in a study of 983, 2-20 year-old participants from a university-based healthy lifestyle program. Attrition was defined as lack of any follow-up within one year of entry and non-completion as not having attended the six required visits within one year after entry. Race and ethnicity predicted both early attrition and non-completion. Non-white, non-Hispanic children were more likely to have early attrition than white non-Hispanic children ($p=.005$; OR = 1.46) and were more likely to be non-completers than white non-Hispanic (OR=1.56) and Hispanic children (OR= 2.56). One-third of participants had early attrition, but a striking 83% were non-completers. Attrition had no relationship to degree of overweight or obesity. Additionally, self-pay or children without insurance were more likely to be early drop-outs ($p=.04$), as were children with public insurance ($p=.05$). This is in contrast to Skelton's (2011) finding in that low BMI was a significant predictor of attrition. Limitations of the study were lack of measurement of other known predictors of attrition, including psychosocial status, quality of life, parental and child motivation, or financial barriers and costs unrelated to program costs (e.g. transportation, time off work) and co-payments. The authors concluded that more information is needed about reasons for these racial and ethnic attrition rates to help modify interventions to improve adherence.

Theim et al. (2013) evaluated the relationship between attendance and adherence to behavioral techniques parents could implement for their overweight children (n=101, ages seven-12, mean 9.9, 71% female). One overweight parent with an overweight child attended a 20-week family-based behavioral weight loss program. Parents were randomized to either a behaviorally or socially focused 16-week program of weight maintenance. Eighty-five percent attended the 20-week family-based behavioral program and 75% attended the 16-week weight maintenance sessions. Higher parental attendance predicted better child weight outcomes at program completion, but not at two-year follow-up. Self-reported adherence to practicing self-regulatory and goal-setting skills (e.g. self-monitoring, self-weighing, re-adjusting to positive course) predicted two-year weight loss outcomes in the behaviorally focused group ($p<001$). The authors hypothesized that attendance served as proxy to adherence for maintaining healthy weight behaviors. These behaviors could potentially reflect enhanced self-efficacy as well as readiness to engage in a weight management program.

Novel technologies such as short message system messaging (i.e. “texting”) have gained popularity to enhance treatment adherence and decrease attrition rates. Simulation and computer modeling of variations has been proposed as a cost-effective alternative to expensive RCTs in real-time. In a systematic review of studies using such approaches, Turner et al. (2015) used wireless and mobile technologies for 12-15 year olds enrolled in adolescent obesity programs. They found longer maintenance phase decreased attrition and increased adherence to self-monitoring and use of behavioral techniques such as improved nutrition and self-monitoring of nutrition. However, it did not improve BMI.

Computer modeling could allow researchers to manipulate variables such as type of intervention, duration, frequency, intensity, and modes of delivery to see quickly which formulations are the most promising in maintaining long-term adherence and maintenance of weight improvements (Wilfrey et al., 2010). Further research of technology needs to explore this identified deficit and other modalities to enhance weight loss.

Many studies have focused on child or family attributes or characteristics that were predictive of negative outcomes, including attrition or poor adherence to weight loss programs and behavioral changes. Catalano et al. (2004) sought to identify positive individual characteristics, such as self-determination, bonding, pro-social involvement, optimism, self-efficacy, and positive identity as predictors of healthy behaviors, adherence and/or positive health outcomes. Themes identified as common to producing effective behavioral change included strengthening social, emotional, behavioral, cognitive and moral competencies; building self-efficacy; and family and community involvement. Effective programs were nine months or longer. Aligned with the Life Course Health Developmental framework (Halfon & Hochstein, 2002), Hoyt et al. (2012) designed an innovative study to examine the association between perceived health, depressive symptoms, and positive well-being in adolescents using data from three waves of the National Longitudinal Study of Adolescent Health (Add Health) from 1994 to 2001 (Harris et al., 2009). The authors reported that positive well-being during adolescence predicted self-reports of excellent general health in young adulthood ($p < .01$) and fewer risky behaviors, such as consumption of fast food and low levels of exercise,

both obesity risk factors. Positive health-related quality of life characteristics such as happiness, enjoyment of life, and hopefulness were found to be more strongly associated with positive health outcomes than self-esteem. This suggests that HRQOL measures might be useful for identifying characteristics of adolescents more likely to adopt and maintain healthy behaviors and adherence to weight management programs.

Readiness for Change

Prochaska (2002) described a theoretical model of stages of change and readiness to improve health-related behaviors. These stages include: Pre-contemplators; Contemplators, and Ready for Action (Prochaska, 2002). Motivational interviewing is used to enhance progression through stages of change, increase the individual's intrinsic motivation, and problem-solve barriers during the change process (Walpole et al, 2011). To increase a child's readiness for healthy weight related changes, it may be important for parents or primary caregivers to be ready to change their personal behaviors and habits.

Evidence supports that parents play a critical role in establishing the child's food environment (Nadar, 1993; Golan, 1998) and food choices (Klesges et al, 1991). Rhee et al. (2005), studied obese children (BMI > 95%; mean age 7.5 years). Mothers in the action stage and ready to commit to recommended lifestyle changes were more likely to perceive their child's weight as a health problem (OR 9.75). It could be hypothesized that this might reflect perceived parent HRQOL.

Jakubowski et al. (2012) examined the predictive value of readiness for change on BMI outcomes in a study of 40 adolescents with polycystic ovary syndrome and their

parents, participating in a weight management program. Participants completed questionnaires assessing stage of change (SOC) in four weight control domains: increasing dietary portion control, increasing fruit and vegetable consumption, decreasing dietary fat, and increasing physical activity at baseline and at program completion. Positive parent change in total SOC from baseline to program completion, suggesting greater adherence to program recommendations, was predictive of adolescent's change in BMI over time ($p=0.043$). Adolescent change in SOC baseline to program completion was not predictive of adolescent change in BMI over that time period. This study adds to the evidence that parents are still very important in achieving positive weight change in their adolescent children and must be motivated to make the necessary dietary lifestyle changes at home. Parental commitment to change is associated with improved adolescent BMI even when the adolescent fails to demonstrate improved readiness for change. Only 70% of the subjects in this study of polycystic ovary syndrome were overweight, so we might anticipate greater adolescent readiness for change in other populations with obesity as their primary and universal concern.

Summary of Review of Literature

Childhood obesity is a worldwide epidemic that may persist and worsen through adolescence and into adulthood. Obesity at any age poses major detrimental risks to physical and psychological health and HRQOL. Adolescence is a critical developmental period in which these psychosocial risks may be accentuated. Thus, it is essential that interventions are evaluated not only regarding weight-related biometric outcomes (BMI, percent body fat), but also psychosocial and functional outcomes. The literature supports

an important relationship between obesity and overweight. Several dimensions of psychosocial and functional HRQOL deficits result from obesity and in many cases also become predictors of increasing obesity. Evidence-based interventions are necessary to reduce childhood obesity. Research has helped to define the characteristics of obesity interventions most likely to result in successful outcomes: cost-free, accessible, multidisciplinary, family- and behaviorally based interventions, inclusion of assessments of readiness for change and motivational interviewing and counseling tailored to the individual, and programs of a duration of one to two years. Well-designed interventions appear to be less effective if children and/or families have low participation or adherence rates. Retention rates appear to vary widely and overall attrition is high. Adherence has been shown to be positively associated with improved outcomes in weight management programs. It is essential to further investigate individual and group factors that may positively and negatively predict optimal adherence to weight management interventions. Health-related quality of life measures broadly assess physical, social, emotional and school functioning. Assessment of HRQOL may help to identify those factors which affect adherence and by extension lead to improved obesity-related outcomes.

CORRELATES OF ADHERENCE TO AN ADOLESCENT WEIGHT MANAGEMENT PROGRAM: A SECONDARY DATA ANALYSIS

Abstract

Purpose Adherence in pediatric obesity programs has been sub-optimal and may be related to psychosocial factors such as health-related quality of life (HRQOL). Obese children with poor levels of HRQOL may not be appropriate candidates for intensive outpatient weight management. The aim of this study was to determine if HRQOL affected adherence to an adolescent weight management program.

Methods This study was a non-experimental, retrospective secondary analysis of data from the REWARD Teens program for overweight and obese adolescents. 37 subjects were included. Subject adherence was the primary outcome variable.

Results There was no significant relationship between HRQOL and program adherence. A significant positive predictive effect for improved adherence was found only when change in BMI ($p=.023$), change of parent-proxy total HRQOL ($p=.014$), and change in child total HRQOL ($p=.007$) were present in the regression model.

Conclusion Collectively, weight loss and changes in both improved and worsening parent-proxy, child HRQOL, and total HRQOL were significantly related to adherence. A potentially novel interplay between factors contributing to program adherence was found. Future studies should focus on elucidating psychosocial interactions which may function as barriers or facilitators to adherence.

Introduction

Childhood obesity rates have tripled over the past 20 years in the United States and in the past 30 years globally [1, 2]. Of American children, 32% are overweight and 16.9% are obese [3,4]. The prevalence rises with age from 12.1% among 2-5 year-olds to 18.4% among 12-19 year-olds [4]. Obese children and adolescents are more likely than non-obese peers to become obese adults [5,6]. Obesity in children and adults has been strongly associated with increased mortality and related co-morbidities, including hyperlipidemia, hypertension, heart disease, diabetes and joint problems, lower-life-expectancy, disability [2,7-9], and with depression, anxiety, low self-esteem or poor self-image [10-12]. Further this heavy burden of chronic disease strains medical and economic resources, as medical costs for obese individuals are approximately 30% greater than for those with normal weight [13].

Behaviorally-based pediatric obesity interventions that aim to prevent or mitigate obesity-related co-morbidities have been largely unsuccessful. Forty-eighty percent of children regain lost weight within one year following weight management programs [8]. Earlier weight loss interventions have primarily focused on improving biometric outcomes such as body mass index (BMI) and percent body fat through improving nutritional and exercise behaviors [14, 20- 21] Prevention of obesity-associated morbidity and mortality requires weight loss and weight maintenance over time. Thus, adherence to long-term healthy lifestyle changes is essential. High attrition rates in adolescent interventions of up to 83% [15, 16] have been identified as a potential barrier to successful weight management. Greater program attendance and completion rates are known to correlate with positive outcomes and greater degrees of weight loss [16, 17- 21]. Understanding how to improve long-term participation rates, an indirect marker for adherence, in weight management programs is essential. There is relatively little research clarifying the influence of health-related quality of life (HRQOL) on adherence and attrition in child weight-management interventions. Intra-personal factors such as self-esteem [22], self-efficacy [23], and well-being [24] have been suggested to influence participation in weight management programs and long-term adherence to healthy behaviors. Health-related quality of life, reflected broadly in such variables has not been well studied as a predictor of adherence.

Health-related quality of life quantifies physical, social, emotional, and school aspects of the child well-being and has been used to delineate how obesity affects the physical and psychosocial function in overweight and obese children. Children who are overweight or obese reportedly have lower levels of HRQOL than their lean counterparts [22,25-27]. Jansen (2013) and Ul-Haaq (2012) found the degree of adiposity was inversely correlated with HRQOL, meaning the more obese the child, the lower the child's HRQOL [28, 29]. Cameron (2013) found a bidirectional relationship between HRQOL and obesity in adults [30]. They found that obese children had lower levels of HRQOL, but also determined that low levels of HRQOL predicted subsequent weight gain and worsening obesity over time. Specifically, lower levels of HRQOL social-emotional functioning were associated with an unhealthy BMI trajectory over time [30, 31]. However, there have been few studies looking at HRQOL as a predictor of adherence to obesity interventions in adolescents.

We conducted a secondary data analysis from an ongoing weight management program for overweight and obese adolescents. The aim was to determine whether HRQOL was related to improved adherence and weight loss. A secondary aim was to determine if child HRQOL, as perceived by the parent, influenced child adherence and BMI. Our *a priori* hypothesis was that adolescents with low HRQOL are less likely to adhere to a weight management program while those with greater HRQOL have greater levels of adherence and improved outcomes.

Methods

Sample and Recruitment for Primary Study

Aggregate data between 2011-2015 was utilized from an ongoing adolescent weight management program, REWARD Teens. The REWARD Teens program is a 12-week, multi-disciplinary weight-management program for overweight and obese adolescents. The program provides a clinic-based, multi-disciplinary, pediatric weight management intervention to improve adolescent weight and weight related outcomes. The REWARD Teens program includes essential elements of treatment programs including nutrition, exercise, and cognitive behavioral therapy using theoretical underpinnings stemming from social cognitive theory [32]. Weekly sessions for parents and adolescents are led by study team members. Adolescents participated in baseline evaluation that included body composition measures, aerobic testing,

and nutrition and physical activity questionnaires. Additionally, behavioral and psychosocial characteristics of the adolescent were assessed with several questionnaires, including parent-proxy and adolescent HRQOL inventories.

Participants were recruited primarily through fliers placed in pediatric primary care settings and by pediatric health provider recommendation during child health visits. Inclusion criteria was children 12-18 years of age who were clinically overweight ($\geq 85^{\text{th}}$ - $< 95^{\text{th}}$ BMI percentile for age and gender; [33] or obese BMI $\geq 95\%$ percentile for age and gender; [33]) with a parent or guardian willing to attend all study visits. Adolescents with significant cardiovascular disease, liver disease, chronic use of medications including diuretics, steroids and adrenergic-stimulating agents, as well as those with diagnosed emotional or psychological problems were excluded.

Sample for Secondary Data Analysis

The sample for secondary analysis included de-identified, aggregate data from 38 subjects. Independent variables were age, race, gender, pre and post intervention BMI, and change in BMI (Δ BMI). Outcome variables were child and parent-proxy health related quality of life (PedsQL), change in HRQOL (Δ PedsQL) for child and parent-proxy, and percent attendance of study visits, a measure used to indicate adherence. The Institutional Review Board approved both the primary and secondary study.

Measures

The Pediatric Quality of Life Inventory (PedsQL; [34]): The PedsQL is a 23-item measure of HRQOL using a five-point Likert scale. The PedsQL yields a global score and subscales to measure the following HRQOL dimensions: physical health, emotional functioning, social functioning, and school functioning [34]. It is self-administered. Both child (ages 2-18) and parent-proxy measures are available. Reliability for the total scale was $\alpha = 0.88$ child self-report and $\alpha = 0.90$ parent proxy-report. Validity was determined by using the known-groups method, correlations with indicators of morbidity and illness burden, and factor analysis [34]. The PedsQL measure distinguishes between healthy children and children with acute or chronic health conditions.

Statistical Analysis

Approximately 38 adolescents and 37 parents were eligible for overall inclusion. Thirteen adolescents had pre and post intervention data. Participant demographics were analyzed using descriptive statistics. An independent t-test was used to compare age, pre-BMI (BMI 1) and post-BMI (BMI 2), child and parent-proxy pre and post total PedsQL mean scores for subjects with pre and post-intervention data (n=13) and for subjects without pre and post-intervention data (n=25) and to evaluate between group differences. Comparisons in gender and race between groups were evaluated using a Chi-square test. A paired t-test was used to compute parental-proxy and adolescent response to the PedsQL pre and post total scales and subscales. Change in PedsQL scores (Δ PedsQL) values were computed by subtracting PedsQL pre-intervention scores from PedsQL post-intervention scores. Delta BMI (Δ BMI) was calculated by subtracting BMI 1 from BMI 2. Adherence was defined as percent attendance, calculated by the number of sessions attended divided by total number of sessions. A linear regression model was computed to determine predictors of adherence and whether Δ PedsQL predicted the degree of adherence. Alpha was set *a priori* at .05 using two sided t-test. Analysis was computed using SPSS version 22 [35].

Results

Table 1 provides descriptive statistics comparing baseline characteristics between adolescents with pre-program only data and pre- and post-program data. Participants with post-intervention data had fewer female subjects (46.2%), younger subjects ($p=.02$), higher percent attendance (mean=.818 vs. .526, SD +/- .15), and were 100% White. Pre- PedsQL child and parent-proxy physical functioning sub-scores (mean difference= 9.66, SD=+/-16.17; $p=.002$) and pre-PedsQL total scores (mean difference= 5.98, SD=+/- 13.32; $p=.016$) were significantly different in the larger sample without pre and post data (n=32). Child mean pre-physical and pre-total mean PedsQL scores were both higher than parent scores in corresponding domains. No other statistically significant differences were found between groups with and without post-intervention data. Further analysis was restricted to data for subjects with pre and post intervention data (n=13). We independently evaluated the relationship between adherence and each of the following: BMI 1, BMI 2, Δ BMI, Δ PedsQL child or parent-proxy total scores or subscale PedsQL scores. We found no significant independent predictive effect with any single variable. When child Δ PedsQL total scores,

parent-proxy Δ PedsQL total scores, and Δ BMI were entered into the model (Table 6), all of these factors became significant predictors of adherence. Weight loss (negative Δ BMI), decreased child total PedsQL, and improved parent-proxy total PedsQL were predictive of greater adherence from pre to post intervention. Neither pre nor post-intervention child PedsQL total or subscale scores predicted adherence. Parent-proxy PedsQL total or subscale scores were not predictive of adherence. There was no statistically significant relationship between adherence and any independent variables (e.g. gender, age, BMI).

Discussion

Baseline child and parent-perceived HRQOL was not an independent predictor of adherence. We observed a statistically significant relationship between the effect of improved parent-perceived HRQOL and adherence in a weight loss management program for adolescents. Interestingly, this was only in those children with decreased HRQOL who had lost weight and had a parent who reported improvement in the child's HRQOL. Weight change, positive or negative, was not an independent predictor of improved adherence. Body mass index could remain unchanged or relatively unchanged even as body fat percentage decreased and muscle or lean body mass increased [36, 37]. Change in BMI may under-report changes in adiposity. Body mass index has inconsistently been identified as a predictor of adherence in weight management programs for children. Skelton & Beech (2011) found subjects with higher BMI had better participation and retention rates in obesity intervention programs, while Dolinsky (2012) found no relationship between adherence and degree of obesity [15, 38]. Alternatively, the twelve weeks of the intervention may not have provided sufficient time for nutritional and exercise behavioral interventions to demonstrate significant BMI changes.

We hypothesized that higher adolescent and parent HRQOL at baseline would predict better adherence to a weight management intervention. Baseline child or parent HRQOL alone did not predict adherence. However, decreased child HRQOL over the 12-week intervention predicted better adherence but only in those with weight loss and whose parents perceived increased child HRQOL did have a significant relationship with adherence. Health-related quality of life alone may not be the best individual-level measure of psychosocial factors which predict adherence in obesity interventions. Body image, body perception and self-esteem all have been identified as moderators or mediators in the relationship between

HRQOL and overweight/obesity [22, 39, 40]. These factors may have influenced the relationship between the variables in our study. It is plausible that adolescents who have poor body image had lower HRQOL scores than those who did not, which might have been elucidated in our analysis. Our findings suggest such a possible interactional effect on HRQOL. Participants with weight loss may have had greater awareness of their actual degree of overweight and less satisfaction with body image, thus increasing motivation for participation despite lower HRQOL.

Our findings suggest that parental recognition of improved child HRQOL in association with weight loss might have facilitated parental participation and adherence. Adherence has been associated with parent and child readiness for change [41,42]. It could be hypothesized that parents who were ready to facilitate healthy changes, and who perceived positive benefits for their children, were more motivated to encourage and facilitate child adherence to weight management program. Wrotniak (2005) reported that both parent and child adherence to weight loss behavioral recommendations were predictive of improved long-term weight changes (i.e. 2 years) [43]. Further, it could be hypothesized that parents with greater adherence possibly institute greater healthy changes in the home environment. Jakubowski (2012) found that parent, but not adolescent, readiness to change for adolescents with poly-cystic ovarian syndrome (PCOS) in an obesity intervention was predictive of improved adolescent BMI [44]. This suggests that parental readiness for change is an important target for weight management. Motivational interviewing may prove to optimize adherence by increasing parental readiness for change. The additive effect we found of improved HRQOL as perceived by the parent supports the importance of parental involvement in child weight management programs, particularly in younger adolescents.

The importance of family involvement in child obesity interventions has previously been found to positively impact adherence, as well as adiposity and psychosocial outcomes [45, 46]. This may be especially important for interventions involving young adolescents, whereby parents still exercise significant influence and control. Children with post-intervention data tended to be younger. Because younger adolescents are still more reliant on their parents, studies involving younger adolescents should consider that parental factors are equally if not more important than they might be in interventions with older adolescents.

Improvement in perceived parent HRQOL of their child may have reflected in improved child's self-image and enhanced self-esteem that was not fully captured by measures of HRQOL. Research has demonstrated that evidence-based interventions can positively impact not only obesity-related biometrics, metabolic parameters, weight outcomes, but also psychosocial and quality of life measures, which may improve even in the absence of improved biometric markers [15, 47]. The addition of behavioral counseling may have contributed additional perceived benefits such as a sense of well-being and self-efficacy that were not fully quantified in this study. Sacher (2010) reported significant improvements in self-esteem, waist circumference, and BMI for children participating in a multi-disciplinary childhood obesity intervention [48]. The researchers suggested improved self-esteem may act as a moderator between program participation and improved weight by enhancing motivation and self-efficacy to continue healthy life-style changes. Catalano (2004) found that children's level of self-efficacy was predictive of health behaviors and positive health outcomes and could directly affect a child's HRQOL [23]. Self-efficacy was not specifically evaluated. However, intervention counseling using SCT directly targets and may have positively influenced self-efficacy. Our findings may have captured elements reflective of self-efficacy that optimized adherence and weight loss. It would be important for future studies to measure self-efficacy as well as HRQOL to better understand the relationship between such variables and their affect on adherence and weight loss.

Contrary to our hypothesis that low HRQOL would predict poor adherence, we found worsening HRQOL predicted increased adherence, but only in the presence of weight loss and improved parent-perceived HRQOL. Depression or other psychological impairments not directly measured may have contributed to reported decline in HRQOL. Co-existing stigma and depression have been correlated with adolescent overweight and obesity [49]. Fulkerson et al. (2004) found that significantly depressed adolescents were more likely to engage in disordered eating behaviors and less able to adhere to improved diet and exercise recommendations [50]. Depression, therefore may contribute to non-adherence and attrition, even in the absence of low HRQOL scores.

Future studies examining predictors of adherence in weight management should include measures of self-efficacy, body image, and parent and child readiness for change, as well as HRQOL. While such

measures are indirectly reflected in HRQOL, combined use of more specific measures might better explain the relationship between psychosocial factors and adherence. By addressing identified factors related to attrition prior to enrollment in obesity interventions, premature attrition might be prevented, thus improving adherence and health-related outcomes.

Limitations

Limitations of this study are the small sample size. We were not able to include all intervention participants because of incomplete post-intervention data. There was incomplete post intervention data for >50% of the original sample size, limiting the sample size of the secondary data analysis, and possibly creating a self-selection bias. It is possible that the small sample size used in analysis resulted in “over-fitting” of the regression model. In addition, the weight management program is located in small rural state and there may be ethnic, geographic, or lifestyle factors influencing BMI and adherence that differ from other areas in or outside the United States. Cognitive and developmental characteristics of mid-adolescence, relative to independence, family and peer relationships, and parental influence may change rapidly in a single year. The behavior of the study group might, therefore differ from that of the older group, biasing our results.

Twelve weeks employed in this intervention might have been an inadequate amount of time to improve healthy behaviors sufficiently to be reflected in improved BMI. Ideal duration of adherence to intervention programs has not been firmly established, but is estimated to be 1-2 years. Longer duration of treatments might reveal a more clear relationship between HRQOL, weight loss and adherence. Finally, BMI may not be the best measure of weight or adiposity outcomes over such a short period of time and it may not take into account changes in lean body mass [51].

Conclusion

We could find few studies that explored the role of adolescent HRQOL as a predictor of obesity intervention adherence. This study advances the literature on adolescent adherence by analyzing perceived parent and adolescent-reported HRQOL as possible predictors of adherence in adolescent obesity pre- and post-interventions. Our findings lend early support to the lack of independent affect of HRQOL on adherence in pediatric weight management programs. Collectively weight loss, decreased child HRQOL,

but improved parent-proxy HRQOL was predictive of increased program attendance rates. These findings provide an important new insight into the interplay between both psychosocial and physiologic variables and program adherence.

Future studies would benefit from a larger, more diverse study group, a longer intervention period and follow-up and include additional measures of child self-efficacy, psychological health, body image, and parent and child readiness to change. It is essential to improve our understanding of factors associated with adherence. Identifying children who are more likely to be successful in weight management programs would allow for better utilization of health resources and optimize weight related outcomes.

Declaration of Interest

None

Table 1 Characteristics between adolescents at baseline and at completion of program.

	Baseline N=25	Completion N=13	p-value
Age (Years)	14.84 ± 0.42	13.46 ± 0.39	0.040*
BMI (wt. (kg)/ht. (m) ²)	33.92 ± 1.39	31.28 ± 1.28	0.227
Attendance (%)	53 ± 6	82 ± 4	0.002*
Child HRQOL Total Score (n=23)	72.73 ± 2.83	79.11 ± 3.56	0.177
Parent HRQOL Total Score (n=21)	66.93 ± 3.32	73.50 ± 4.46	0.239

* significant at p <0.05

Table 2 Relationship between body mass index, change in child HRQOL and parent-proxy total HRQOL and adherence (n=13).

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	.820	.039		20.822	.000
post minus pre C total	-.009	.005	-.526	-1.671	.126
post minus pre P total	.005	.004	.458	1.455	.176
2 (Constant)	.757	.038		19.753	.000
post minus pre C total	-.022	.006	-1.293	-3.463	.007*
post minus pre P total	.011	.003	.888	3.043	.014*
post minus pre BMI	-.086	.031	-.887	-2.728	.023*

Dependent variable: attendance

*p < 0.05 level

C=child; P=parent

* significant at p <0.05

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