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PHYSICAL ACTIVITY, PHYSICAL FITNESS AND THE PSYCHOSOCIAL WELL-BEING OF OBESE ADOLESCENTS

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PHYSICAL ACTIVITY, PHYSICAL FITNESS AND THE PSYCHOSOCIAL WELL-BEING OF OBESE ADOLESCENTS

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science at Virginia Commonwealth University

by

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Abstract

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By Nichole R. Kelly, B.S.

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Virginia Commonwealth University, 2009

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Overweight and obesity are associated with an array of negative physical and psychosocial symptoms in adolescents. Numerous pediatric obesity interventions have emerged in an attempt to address this significant public health concern. However, few have focused on African American females, a particularly high risk group for negative health behaviors and associated complications. Moreover, research examining the psychosocial changes associated with increases in physical activity and fitness, although promising in elder and adult populations, is nearly nonexistent in adolescents. Thus, the current study addressed limitations in the research and examined the psychosocial outcomes of adolescent participants in T.E.E.N.S., a culturally sensitive, multidisciplinary weight loss intervention. From baseline to 6 month post-testing, program participants demonstrated significant improvements in physical, emotional,
and social functioning, as well as body dissatisfaction. Moreover, increases in physical activity and cardiorespiratory fitness were associated with significant enhancements in several domains of psychological well-being.
Introduction

A number of environmental and behavioral factors have contributed to the exponential increase in pediatric overweight since the 1970’s (Barlow & Expert Committee, 2007; Joliffe, 2004). Currently, over one third of children between the ages of 2 and 19 years are obese or overweight (Ogden, Carroll, Curtin, McDowell, Tabak, & Flegal, 2006). These rates appear to be increasing most rapidly in 12- to 19-year old African American youth (Ogden et al., 2006). In this group, obesity rates have increased by 15%, compared to 7% among White adolescents (Ogden et al., 2006).

Overweight and obesity among children and adolescents are concerning because they are associated with a number of negative physical (Speiser et al., 2005) and psychosocial symptoms (Hesketh, Wake, & Water, 2004; Tsiros et al., 2009; Walker, Gately, Bewick, & Hill, 2003), many of which are likely to track into adulthood (Epstein, Meyers, Raynor, & Saelens, 1998; Freedman et al., 2005; Petry, Barry, Pietrzak, & Wagner, 2008). The marked consequences of pediatric obesity have prompted intense research efforts aimed at identifying factors influencing the increase in obesity prevalence. Although a single cause has not been identified as the catalyst for the pediatric obesity epidemic, researchers have focused on a number of variables including increased caloric intake, poor dietary choices, familial dysfunction and environmental pressures. Of particular concern is the marked decrease in physical activity in youth (Pate et al., 2002; Centers for Disease Control, 2006), as exercise infrequency during
adolescence is consistently associated with poor psychological well-being (Kirkcaldy, Shephard, & Siefen, 2002; Page & Tucker, 1994).

This study examined the effects of physical activity and physical fitness on the psychosocial outcomes of adolescent participants in a culturally sensitive, multidisciplinary weight loss intervention: Teaching, Encouragement, Exercise, Nutrition, and Support (T.E.E.N.S.). Specific outcomes examined included body dissatisfaction, depression, and health-related quality of life (HRQOL). T.E.E.N.S. was designed to meet the needs of an inner-city population of overweight youth, the majority of which are severely obese African American female adolescents from low socioeconomic status (SES) and single-parent families (Stern et al., 2007).

Although research suggests that African American female adolescents are at high risk for low levels of physical activity and poor quality of life (QOL), only a handful of studies have investigated these variables in this population (Resnicow et al., 2000; Yin et al., 2005). Therefore, the T.E.E.N.S. intervention provides an important opportunity to examine the effects of physical activity on the psychosocial well-being of this high risk group.

Defining Pediatric Overweight and Obesity

“Obese” and “overweight” are currently defined by a body mass index (BMI) equal to or greater than the 95th and 85th percentile (Barlow & Expert Committee, 2007), respectively, for age and gender according to the 2000 Centers for Disease Control growth charts (Kuczamarski, Ogden, Guo, Grummer-Strawn, & Flegal, 2002). For older
adolescents, obesity is defined as a BMI $\geq 95$th percentile or $\geq 30 \text{ kg/m}^2$, whichever is lower.

These current guidelines represent a change from the preceding expert recommendations, which defined a BMI greater than the 95th percentile as “overweight” and a BMI greater than the 85th percentile as “at-risk for overweight” (Kuczamarski et al., 2002). The recent language changes parallel terms used to define adult obesity and are expected to strengthen clinical awareness of the risks associated with elevated adiposity in children and adolescents (Barlow & Expert Committee, 2007). Therefore, terminology reported in studies referenced throughout this paper prior to 2007 has been adjusted to reflect the most current obesity and overweight definitions.

*Physiological Effects of Pediatric Obesity*

Obese adolescents are at increased risk of developing a variety of debilitating and chronic medical conditions including Type 2 diabetes mellitus, hypertension, liver disease, and premature osteoarthritis (Dietz, 1998; Speiser et al., 2005). The number of pediatric cases of Type 2 diabetes mellitus, a disorder which until recently had rarely been seen in children (Ogden, Flegal, Carroll, & Johnson, 2002; Speiser et al., 2005), increased 10-fold between 1982 and 1992 (Pinhas-Hamiel et al., 1996). More than 90% of children with Type 2 diabetes mellitus had a BMI above the 90th percentile (Pinhas-Hamiel et al., 1996). Further, impaired glucose tolerance and cardiovascular disease are serious and chronic conditions associated with pediatric obesity (Goran, Ball, & Cruz, 2003; Weiss, et al., 2004).
In older adolescents, a BMI at or above the 95th percentile is related to elevated blood pressure and blood lipid profiles, increasing risks of additional obesity-related disease and mortality (Barlow and Dietz, 1998). Further, studies of obese children have found that over 90% suffer from some sort of sleep abnormality (Zametkin, Zoon, Klein, & Munson, 2004), most often sleep apnea (Marcus et al., 1996; Silvestri et al., 1993). These types of sleep-related problems can have considerable clinical implications. For example, children with obstructive sleep apnea demonstrate significant decrements in learning and memory function (Rhodes et al., 1995).

*Psychosocial Effects of Pediatric Obesity*

In addition to poor health, research has found that obese adolescents often manifest low health-related quality of life (HRQOL) compared to their normal weight peers (Schwimmer, Burwinkle, & Varni, 2003; see Tsiros et al., 2009 for a review), as well as greater body dissatisfaction, lower global self-worth (Walker et al., 2003), and lower self-esteem (Hesketh et al., 2004). Further, Schwimmer and colleagues (2003) reported that obese adolescents seeking weight-related treatment obtained HRQOL scores similar to those of children with cancer undergoing chemotherapy.

Research has also shown that adolescents seeking weight loss treatment are at particular risk for poor psychological well-being compared to non-treatment seeking obese or normal weight community peers (Braet, Mervielde, & Vandereycken, 1997; Britz et al., 2000; Wardle & Cook, 2005). When samples of referred versus non-referred overweight youth were assessed, those referred for treatment demonstrated greater anxiety and social withdrawal, as well as more severe eating pathology and increased
internalizing symptoms (Vlierberghe, Braet, Goossens, & Mels, 2009). Taken together, research suggests that obesity has a significant and negative impact on both the physiological and psychosocial health of overweight and obese adolescents, especially those seeking weight-related treatment.

*Physical Activity, Physical Fitness, and Quality of Life*

Sedentary behaviors are consistently one of the strongest predictors of adolescent obesity (Saelens, 2003). It has been suggested that television watching, as well as other popular sedentary behaviors such as computer and video game use, detract from time spent participating in physical activities (Epstein, Roemmich, Paluch, & Raynor, 2005). An international consensus group and the U.S. Department of Health and Human Services recently recommended that youth participate in at least 60 minutes of daily physical activity (Cavill, Biddle, & Sallis, 2001; USDHHS, 2005). However, it was recently estimated that only 35.6% of adolescents are meeting this physical activity guideline, and rates are even lower for females, minorities, and economically disadvantaged youth (Centers for Disease Control, 2006; Pate et al., 2002).

In fact, research has shown that children currently spend only 1.4% of their day (Strauss, Rodzilsky, Burack, & Colin, 2001), or approximately 8 - 12 minutes, in vigorous or aerobic activity (Janz, Golden, Hansen, & Mahoney, 1992). In a nationally representative sample of 54,000 high school youth, participation in physical education decreased 57% between 8th and 12th grade (Johnston, Delva, & O’Malley, 2007). There is also evidence that consistently low levels of physical activity in childhood may have long-term implications, as such activity habits continue in adulthood (Friedman et al.,
In other words, inactive children are likely to remain inactive as adults. Thus, the general increase in sedentary behavior and increasingly insufficient levels of physical activity are of particular concern as research suggests that they have a significant negative and potentially long-term impact on adolescents’ well-being (Ferron, Narring, Cauderay, & Michaud, 1999; Page & Tucker, 1994; Piko & Keresztes, 2006). Similarly, regular physical activity, including strength training (Faigenbaum, 2000), has proven to be quite effective in combating, and potentially preventing, negative affect and psychopathology in youth (Kirkcaldy et al., 2002; Mutrie & Parfitt, 1998; Shoup, Gattshall, Dandamudi, & Estabrooks, 2008).

Adolescents reporting improvements in indicators of physical fitness, or “the capacity to perform physical activity,” such as cardiorespiratory fitness, have also experienced enhancements in psychological well-being (Ortega, Ruiz, Castillo, & SjÖstrom, 2008, p.1). Cardiorespiratory fitness refers to “the body’s ability to transport and use oxygen” (p. 314; American College of Sports Medicine, 2006). The World Health Organization (WHO) considers VO2max, an assessment of peak oxygen consumption ascertained during incremental exercise, to be the best indicator of cardiorespiratory fitness (Ortega et al., 2008; Shephard et al., 1968). The psychosocial benefits associated with increased aerobic fitness have been maintained in adult populations at one year follow-up, independent of increased participation in physical activity, and thus exhibit potential long-term implications (DiLorenzo et al., 1999). It therefore seems imperative to consider both physical activity and indicators of physical fitness (e.g., VO2max) when examining the association between exercise and quality of
life. However, relatively little research has examined the association between these variables; in particular studies are needed that examine these links in obese youth.

Several mechanisms by which physical activity improves quality of life have been proposed. Some researchers suggest that the benefits are the results of neurochemical changes in the brain (i.e., increased serotonin, dopamine, and/or endorphins; Ortega Ruiz, Castillo, & Sjostrom, 2008; Stella et al., 2005). Ortega and colleagues (2008) further propose that changes in appearance as the result of increased physical activity and/or fitness, such as decreased body mass, may account for the noted enhancements in body image, among other psychosocial indicators. At this time, no single explanation of the mental health advantages of physical activity has been identified. It is likely a combination of factors that contribute to such a relationship.

**Health-Related Quality of Life**

**Associations with adolescent obesity.** Results of research investigating the HRQOL of obese adolescents are mixed (Zeller & Modi, 2006; Tsiros et al., 2009). HRQOL is a construct that includes four separate domains of well-being: emotional, social, school and physical (Schipper, Clinch, & Olweny, 1996; Varni, Burwinkle, Seid, & Skarr, 2003). Typically, overweight and obese children and adolescents report significant impairments in HRQOL, although the degree of this impairment varies somewhat across studies. Some research suggests that HRQOL is roughly equivalent across samples of obese and normal weight community, or non-treatment-seeking, teens (Zeller & Modi, 2006). However, HRQOL is significantly lower among overweight and obese youth seeking weight loss treatment (Pinhas-Hamiel et al., 2006; Schwimmer et al.,
It has also been noted that adolescents seeking weight-related assistance often have higher BMIs than their community peers (Erermis et al., 2004). Further, research shows that an inverse relationship exists between HRQOL and BMI (Erermis et al., 2004; Tsiros et al., 2009; Williams et al., 2005). This inverse relationship between BMI and HRQOL might partially account for the lower HRQOL in treatment-seeking samples.

Additionally, in a cross-sectional study investigating differences in the HRQOL of obese and normal weight youth, Pinhas-Hamiel and colleagues (2006) found that as BMI increased, individual’s perceptions of his or her physical abilities (i.e., physical functioning) decreased (Pinhas-Hamiel et al., 2006), findings which have been replicated in other studies with both adolescents (Schwimmer et al., 2003) and children (Hughes, Farewell, Harris, & Reilly, 2007). This relationship may reflect difficulties in movement, low perceived ability to move, or low self-efficacy regarding physical activity. Self-efficacy to be active (Neumark-Sztainer et al., 2003) and perceived activity competence (Sallis, Prochaska, & Taylor, 2000) have both been linked with increased motivation for and participation in physical activity.

**Associations with physical activity and physical fitness.** Despite the association between HRQOL and obesity, few researchers have investigated interventions aimed at increasing HRQOL in obese adolescents (Fullerton et al., 2007). Moreover, no study has specifically examined the relationship between changes in physical activity and the HRQOL of obese adolescents, despite research identifying associations among exercise and reductions in depressive symptoms (Mutrie & Parfitt, 1998) and improved self image.
One cross-sectional study of 177 overweight and obese children (8 to 12 years old) reported a significant relationship between physical activity and HRQOL (Shoup et al., 2008). Specifically, compared to less active participants, children who self-reported participation in the recommended physical activity requirements (i.e., at least 60 minutes of daily moderate to vigorous activity) also endorsed greater psychosocial, physical and overall QOL, regardless of weight.

Therefore, interventions aimed at increasing physical activity may have positive effects on adolescents’ physical self-efficacy and perceptions of physical functioning, potentially increasing HRQOL. To date, Sagatun and colleagues (2007) are the only researchers who have assessed the longitudinal relationship between physical activity and mental health in adolescents. While their findings provide important information for future research efforts regarding the potential protective factors of physical activity, some limitations should be noted. First, Sagatun et al.’s sample included non-overweight adolescents and is thus limited in its generalizability to overweight and obese populations. In addition, the authors utilized a self-report, single item questionnaire to assess weekly physical activity. Although shorter questionnaires reduce participant burden, single item scales typically suffer from low reliability (DeVellis, 2003). Thus, studies using more reliable and comprehensive methods of assessing physical activity, as well as physical fitness, are needed.

**Depression**

*Associations with adolescent obesity.* Teenagers who rarely exercise are more likely to become obese (Patrick et al., 2004) and experience loneliness, shyness, and
feelings of hopelessness (Page & Tucker, 1994). In one study of treatment-seeking obese children and adolescents, 50% were classified as depressed (Sheslow, Hassink, Wallace, & De Lancey, 1993). Moreover, it has been suggested that depression mediates the relationship between obesity and QOL (Janicke et al., 2007). In a nationally representative sample of 4648 adolescent boys and girls between the ages of 10 and 18 years, higher levels of depression were associated with eating disordered behaviors and suicidal ideation (Glied & Pine, 2002). Another study found that obese adolescents recruited from the community reported lower expectations of their educational future and higher emotional distress, compared to their normal-weight peers (Mellin, Neumark-Sztainer, Story, Ireland, & Resnick, 2002). Moreover, obese teenagers of both genders and diverse ethnicities who reported experiencing weight-related teasing manifested high levels of depressive symptoms and suicidal thoughts (Eisenberg, Neumark-Sztainer, & Story, 2003).

In an effort to escape weight-related jokes and teasing, overweight and obese adolescents may also be prone to social isolation, which has been linked to feelings of shame and increased risk for depression (Sjöberg, Nilsson, & Leppard, 2005). In addition, overweight youth who are teased report avoiding physical activity for fear of being ridiculed (Storch, Milsom, DeBraganza, Lewin, Geffken, & Silverstein, 2007). It has also been suggested that depression may lend to lower levels of physical activity, given a depressed person’s lack of motivation, fatigue, and/or loss of energy (Gray, Janicke, Ingerski, & Silverstein, 2008). Thus, for a myriad of reasons, overweight youth are more likely to prefer sedentary and solitary activities (Hayden-Wade et al., 2005). Such
avoidance not only prevents adolescents from participating in physical activity but also minimizes opportunities for peer-group interactions, which are hypothesized to buffer the negative effects of victimization (Prinstein, Boergers, & Vernberg, 2001). As a result, overweight youth experiencing weight-related stigma often find themselves caught in a cycle of social isolation, internalizing symptoms, and inactivity (Kelly, Gow, Mazzeo, & Stern, 2009). Moreover, literature further suggests that depressive symptomatology is associated with poor adherence to and attrition from weight management programs (White et al., 2004).

*Associations with physical activity and physical fitness.* A handful of studies have identified a significant association between physical activity, physical fitness, and depressive symptoms in adolescents. One such study included 40 Brazilian obese, female adolescents who were randomly assigned to one of four arms of a physical activity intervention: aerobic exercise, anerobic exercise, leisure activity and no activity. Those participating in the aerobic exercise condition demonstrated significant reductions in depression scores at post-testing (Stella et al., 2005). Additional research suggests that more active youth have higher levels of life satisfaction and global self-worth (Daley, Copeland, Wright, Roalfe, & Wales, 2006), whereas children who participate in very little or no physical activity exhibit more depressive symptomatology (Ferron et al., 1999; Piko & Keresztes, 2006).

Furthermore, improvements in physical fitness have been linked to decreased negative affect. In a study of 66 low-income Hispanic children, participants were randomized to either an intensive aerobic exercise group or a less intensive exercise
Participants in the intensive program \((N = 34)\) experienced greater increases in cardiorespiratory fitness and self-esteem, as well as significant depressive symptom reduction, compared to those youth in the less intensive group \((N = 32)\).

In addition to these few longitudinal studies reviewed above, several other cross-sectional investigations have also suggested a link between exercise and depressive symptomatology. However, it is important to note that causal relationships cannot be determined based on cross-sectional data. Nonetheless, data from a large community sample suggested that low recreational activity at baseline assessments predicted the presence of depressive symptomatology in White adult women approximately eight years later (Farmer et al., 1988). Similarly, Motl, Birnbaum, Kubik, & Dishman (2004) found a significant and inverse relationship between physical activity and negative affect over the course of two years in a community sample of adolescents. While Motl et al.’s results parallel the findings of studies using older populations, it is important to note that their methodology was limited by the single item assessment of physical activity which assessed time spent exercising outside of school. Additional research is needed which includes a more comprehensive assessment of physical activity in children in variety of settings.

The majority of existing research examining the relationship between changes in exercise and mood has focused on adults and the elderly population. Thus, more extensive longitudinal research examining the trajectory of these factors is warranted in
children and adolescents. Nonetheless, it is important to consider findings from adult samples which might have significant implications for adolescents.

In one literature review examining 10 key randomized controlled studies, two conclusions were drawn regarding the relationship between physical activity and depression (Mutrie & Parfitt, 1998). First, physical activity is associated with a decreased risk of developing depression. In addition, aerobic activity and resistance training are effective, long-term treatment options for depression and yield benefits comparable to those of psychotherapeutic interventions (Shepard, 1995; Motl et al., 2005). Although Mutrie and Parfitt (1998) reported findings based on the adult population only, they also concluded that exercise may serve as a protective factor against adult depression, given that individuals who are physically active as children and teenagers are more likely to maintain their healthy activity patterns into adulthood (Nelson, Gordon-Larsen, Adair, & Popkin, 2005). Overall, these findings support the need for similar investigations with youth populations, and suggest that participating in physical activity during adolescence may have positive and long-term mental health implications.

A related review on the effects of exercise on depression in adults concluded that the benefits of activity are equal across age, gender, and health status (North, McCullagh, & VuTran, 1990). The literature also suggests that both aerobic and non-aerobic exercises, such as strength and flexibility training, are equally effective in reducing depressive symptoms (Martinsen, 1990; Martinsen, Hoffart, & Solberg, 1989; North et al., 1990).
Body Image

Associations with adolescent obesity. The strongest relationship between obesity and self-esteem can be seen when appearance is the primary domain of self-esteem measured (French, Story, & Perry, 1995). Indeed, self-esteem is more strongly associated with reported levels of body image dissatisfaction than to actual body mass (Kostanski & Gullone, 1998). Perhaps not surprisingly then, obese girls tend to report lower self-esteem and higher body dissatisfaction compared to obese boys (Israel & Ivanova, 2002; Jelalian & Saelens, 1999). Further, the impact of BMI on body dissatisfaction appears to be moderated by age. Specifically, obese adolescents manifest higher body dissatisfaction than obese children. Body image concerns are particularly alarming because they have been identified as risk factors for both eating disorders (Stice, Presnell, & Spangler, 2002) and depression (Stice & Bearman, 2001).

Associations with physical activity and physical fitness. Participating in physical activity has also been linked to improvements in body image (Burgess, Grogan, & Burwitz, 2006; Ferron et al., 1999; Goldfield et al., 2007; Williams & Cash, 2001). One study examined the impact of a five month walking program on middle-aged men and found that improved aerobic capacity was associated with enhanced physical esteem, findings which may generalize to younger adults and teenagers (McAuley, Mihalko, & Bane, 1997).

One study which did include children was conducted by Goldfield and colleagues (2007). These authors utilized a randomized controlled trial to investigate the relationship between physical activity and psychosocial adjustment in 8- to 12-year old children.
Results indicated that increased activity was associated with improvements in several domains of physical self-worth, including perceived physical conditioning and body satisfaction. Similarly, strength training has been associated with improvements in body satisfaction in college-aged males and females (Williams & Cash, 2001). Moreover, exercise has been linked to positive emotional well-being in adolescents (Steptoe & Butler, 1996), as well as higher life satisfaction and happiness across the lifespan (Stubbe, de Moor, Boomsma, & de Geus, 2007). Some authors hypothesize that this association may be due to an enhanced sense of mastery or exercise-related self-efficacy (Schmalz, Deane, Birch, & Davison, 2007; Strauss et al., 2001). Although a handful of cross-sectional studies have reported a link between physical activity and positive body image (Burgess et al., 2006; Ferron et al., 1999), the longitudinal contributions of increased exercise, especially fitness, on body dissatisfaction in adolescents remain unexamined.

**High Risk Groups**

*Gender and age.* Factors such as gender, age, and racial/ethnic group membership appear to influence risk for pediatric obesity. Gender plays a significant role in the relationships among physical activity, obesity status, and psychosocial well-being. For example, socio-cultural pressures exist for boys to conform to an idealized, muscular physique. Such pressures are associated with poor psychological adjustment, eating disorders, steroid use, and exercise dependence (McCabe & Ricciardelli, 2004). In contrast, socio-cultural pressures to attain an extremely thin body type are intense for girls (McCabe & Ricciardelli, 2001). As a result, female adolescents are particularly at
risk for weight-related psychosocial complications, including Anorexia Nervosa and Bulimia Nervosa (Ricciardelli & McCabe, 2001).

The adolescent years are a particularly difficult time for girls as pubertal body fat typically increases at the same time that societal pressures to be thin strengthen (Striegel-Moore, Silberstein, & Rodin, 1986). As a result, young girls become acutely aware of the stigma associated with being overweight and some subsequently engage in increased levels of maladaptive eating behaviors (Young-Hyman, Schlundt, Herman-Wenderoth, & Bozylinksi, 2003). Further, childhood obesity is considered a risk factor for the development of both Binge Eating Disorder (Fairburn et al., 1998) and Bulimia Nervosa (Fairburn, Welch, Doll, Davies, & O’Connor, 1997).

In addition, despite the relatively equivalent obesity prevalence rates in males and females as of 2003-2004 (Ogden et al., 2006), obese girls report lower levels of body image satisfaction and self-esteem compared to obese boys (Huang, Norman, Zabinski, Calfas, & Patrick, 2007; Israel & Ivanova, 2002). Such discrepancies are likely due to gender differences in body image ideals and the significant value placed on physical appearance for young women (Presnell, Bearman, & Stice, 2004). Also, parental feedback about weight is typically more negative for girls than for boys (Levinson, Powell, & Steelman, 1986) and such feedback is associated with higher levels of body dissatisfaction and disordered eating symptoms (Wertheim et al., 1992).

Research has also shown that obese females between 13 and 16 years of age have lower self-esteem scores compared to their younger counterparts (Stradmeijer, Bosch, Koops, & Seidell, 2000). Further, during their pre-teen and teen years, weight concern
and body dissatisfaction among females with higher BMIs increases with age (Davison, Markey, & Birch, 2003). Moreover, overweight girls’ levels of physical activity, self-esteem, body image, and general quality of life decrease over time (Strauss et al., 2001). Before 13 years of age, girls and boys participate equally in physical activity (Strauss et al., 2001). However, as boys and girls continue through adolescence, boys became significantly more active than their female counterparts. When comparing pre-teen and teenage girls, physical activity decreased by more than 35% between the ages of 10 and 16 (Strauss et al., 2001). Taken together, these findings suggest that the obese female adolescent population is more prone to unhealthy levels of sedentary activity and more likely to experience weight-related psychosocial complications.

*Race/Ethnicity.* Interestingly, studies examining obese African American adolescents have not found an association between obesity and appearance self-esteem (Young-Hyman, et al., 2003). African American females, ages 6 – 19, have the highest rates of adolescent obesity of all racial/ethnic and gender groups in the United States (Ogden et al., 2006). Furthermore, the risk of becoming obese between childhood and young adulthood is about 1.5 times greater for African American girls than for White girls (Thompson et al., 2007), placing them at an increased risk of major health complications throughout both adolescence and adulthood (Wadden et al., 1990). In addition, African American females report the highest levels of sedentary behaviors and the lowest levels of physical activity (Grunbaum et al., 2002; Ogden et al., 2002). They are also less likely than their peers to meet recommended dietary guidelines (Grunbaum et al., 2002; Ogden et al., 2002). Further, by the time they turn sixteen, over half of
African American teens do not participate in any leisure physical activity, and their median activity level declines by 100% before the age of 18 (Kimm et al., 2002). As a result, African American children are also at a higher risk for Type 2 diabetes mellitus (Rosenbloom, Joe, Young, & Winter, 1999), certain heart diseases, and stroke as adults (Karter et al., 1998).

Despite higher obesity rates, research suggests that African American girls consider themselves to be attractive and socially acceptable at a higher BMI than White girls (Padgett & Biro, 2003). Studies suggest that African American females do not prefer the ultra thin body type so eagerly sought by middle and upper-class White females (Wadden & Stunkard, 2002). Moreover, in a 2003 study of 117 obese and very obese African American children and adolescents, only 30% of the parents rated their children as overweight, demonstrating a lack of knowledge regarding their children’s obesity status and associated health complications (Young-Hyman et al., 2003).

Parents’ lack of awareness regarding their children’s overweight status may explain why obese African American adolescents manifest less psychological distress than their White peers. Parents or caregivers might not be communicating negative attitudes to their children regarding size (Young-Hyman, Herman, Scott, & Schlundt, 2000). Their relative lack of weight preoccupation might also be contributing to the near nonexistence of physical activity and associated marked degree of obesity in African American females (Wadden & Stunkard, 2002). Therefore, culturally appropriate interventions must be designed to help African American adolescent girls and their
parents understand the long-term health consequences of obesity and the benefits of adopting an active lifestyle without encouraging body dissatisfaction.

The apparent acceptance of a larger body type may have protected the African American community from lower self-esteem and body dissatisfaction, but may also be problematic if the physical hazards associated with obesity are unrecognized. Further, more recent research proposes that severely obese African American boys and girls manifest impairments in psychological well-being comparable to that of their severely obese White peers, suggesting that extreme levels of obesity might mitigate “any protective mechanisms often associated with being male or African American and dealing with the negative psychosocial effects of high BMI” (Stern et al., 2007, p.93). Although the African American female adolescent population is particularly at-risk for poor health and extremely low levels of physical activity, research examining this particular group within treatment-seeking settings is limited.

*Intervention Efforts*

As awareness of epidemic levels of childhood obesity has increased, the number of weight management programs focusing on children and adolescents has grown exponentially. Although the need for such interventions appears strong, concern has been expressed regarding their potential iatrogenic effects (O’Dea, 2005). Specifically, concerns have been raised that interventions targeting obese adolescents could contribute to unhealthy eating and physical activity obsessions which might develop into eating disorders (Epstein, Paluch, Saelens, Ernst, & Wilfey, 2001; Huang et al., 2007; Lawrence & Thelen, 1995). Still others suggest that participation in weight loss programs might
incidentally weaken coping mechanisms and induce feelings of failure if weight loss goals are not met (Cameron, 1999). Therefore, it has been argued that the psychosocial outcomes of pediatric obesity interventions are as important as the medical/anthropometric outcomes (including weight loss; Braet, Tanghe, Decaluwe, Moens, & Rosseel, 2004; Jelalian & Saelens, 1999; Striegel-Moore, 2001). In response, a number of researchers have investigated the effects of weight-loss interventions on the health and well-being of participants.

For example, Yin and colleagues (2005) examined one year follow-up data from the Medical College of Georgia’s FitKid Project, an after-school program designed to increase moderate-to-vigorous physical activity in youth from low socioeconomic backgrounds, 61% of whom were African American. Results showed that adolescents with at least moderate attendance rates (>40%) demonstrated lower body fat percentages and greater gains in bone mineral density and cardiovascular fitness, regardless of baseline obesity status, compared to the control group. This study supported prior research suggesting that 30-60 minutes of moderate-to-vigorous physical activity per day is capable of improving the body composition and health of adolescents (Gutin, et al., 2002). Similar conclusions were reported with a sample of obese, Korean adolescent girls (Park, Hong, Lee, and Kang, 2007). Compared to a no treatment control group (N = 22), girls participating in a 12-week exercise intervention (N = 22) showed greater reductions in body weight, BMI and percent body fat, as well as decreased cardiovascular risk (e.g., reductions in insulin, glucose, and systolic blood pressure).
A third investigation reported the long-term effects of an obesity intervention on weight status and cardiovascular disease risk factors in a sample of 203 obese German children aged 6-14 years (Reinehr, de Sousa, Toschke, & Andler, 2006). The “Obeldicks” intervention involved increasing physical activity, reducing the amount of time spent watching television, nutrition education, and behavioral therapy. Compared to children who did not participate in the intervention, participants exhibited decreases in BMI accompanied by improvements in blood pressure and insulin and cholesterol concentrations, results comparable to the effects of pharmacological therapy. The reported reductions in weight loss were maintained at four-year follow-up (Reinehr, Temmesfeld, Kersting, de Sousa, & Toschke, 2007).

Other intervention studies have examined psychosocial outcomes. Specifically, interventions focused on increasing the amount of time spent in physical activity have resulted in improvements in psychosocial well-being, including enhanced body image, self-esteem, and global self-worth (Braet et al., 2004; Huang et al., 2007; Jelalian, Mehlenbeck, Lloyd-Richardson, Birmaher, & Wing, 2006; Walker et al., 2003).

PACE (the Patient-Centered Assessment and Counseling for Exercise Plus Nutrition Project) is a year-long intervention for children during which diet, physical activity, and sedentary behaviors are targeted (Huang et al., 2007). In a one year follow-up of over 650 boys and girls, no impairments on self-esteem or body dissatisfaction were demonstrated collectively, regardless of weight change or group assignment (PACE vs. a control group; Huang et al., 2007). In fact, girls who experienced weight reduction or maintenance in the intervention group reported improved body image satisfaction.
scores compared to those who gained weight (Huang et al., 2007). In the same study, boys reported increased self-esteem scores regardless of group assignment or weight change-status.

Another study examined anthropometric and psychosocial changes in 57 obese adolescents participating in a weight loss camp. Campers participated in several one hour fun-based, skill-enhancing physical activity sessions per day (Walker et al., 2003). Measures were administered at baseline and upon the camp’s completion (approximately 4 weeks later). Results indicated that those who stayed for 4-6 weeks experienced increased global self-worth, athletic competence, physical appearance esteem, and self-esteem, as well as decreased body dissatisfaction. Similarly, Braet and colleagues (2004) found that body dissatisfaction and eating pathology were significantly reduced in 7-17 year olds during 10 months of inpatient treatment for obesity, and remained significantly lower at 14-month follow up compared to baseline. Two years after the program’s completion, 82% of the sample had succeeded in reducing their BMI by at least 10% from the time of enrollment. Further, psychopathology composite scores and eating disorder symptoms declined significantly, whereas global self-worth increased significantly. The researchers also noted that weight loss was higher for program participants older than 12, suggesting that weight control may require self-control skills that older children are better able to master.

“Peer-enhanced adventure therapy,” is a cognitive-behavioral treatment program for adolescents which relies on peers to support change (Jelalian et al., 2006). One study compared the effectiveness of two 16-week cognitive-behavioral weight control
programs, one with a peer-enhanced adventure therapy component and one with an aerobic exercise component. Initial results showed significant reductions in BMI for both intervention groups. However, results from the 10 month follow-up differed. Approximately 23% of participants assigned to the adventure therapy intervention maintained a 10% weight loss after 10 months, compared to 4% of those assigned to the aerobic exercise intervention. Members of both treatment conditions demonstrated significant improvements in global self-concept, physical appearance, and physical self-worth. Research has consistently shown that adolescents, especially those 14-16 years old, are particularly influenced by their peers (Steinberg & Morris, 2001). The positive outcomes of adventure therapy may therefore be a direct result of the addition of the peer-based component. Further, some researchers have suggested that attention and support from fellow participants may be the main causes of improved well-being (Walker et al., 2003; Wardle & Cooke, 2005).

During adolescence, peer influence becomes an important determinant of many health-related behaviors, both positive and negative (Rai et al., 2003). For example, Anderson and Wold (1992) demonstrated that peer support for and participation in physical activity is associated with increased activity among youth. Further, research has shown that peers may serve as models of positive health behaviors (Hattie, Marsh, Neill, & Richards, 1997). In the presence of friends and peers (versus alone), 12 to 14 year old overweight and lean youth demonstrated a greater desire to be active rather than sedentary (Salvy et al., 2008b). Moreover, overweight youth (compared to lean youth)
participated in physical activity longer and more intensely (Salvy et al., 2008a) in the presence of both friends and peers than when alone (Salvy et al., 2008b).

Additional studies have found that peer-based support for physical activity is correlated with moderate and vigorous physical activity levels for adolescent females (Neumark-Stzainer et al., 2003; Springer, Kelder, & Hoelscher, 2006). Thus, increases in perceived social support for activity would likely result in an individual’s increased participation in physical activity (Neumark-Stzainer et al., 2003). Furthermore, research by Salvy and colleagues (2008a) suggests that overweight youth spend more time alone compared to normal weight youth. When alone, youth are less inclined to participate in intense physical activity. Therefore, adolescent weight management interventions that encourage and develop peer support and provide opportunities for peer interactions might be effective at increasing the duration and intensity of physical activity, in addition to enhancing psychosocial well-being.

In summary, research strongly suggests that programs focusing specifically on increasing physical activity, in conjunction with a peer-based component, can enhance the health and well-being of participants (Huang et al., 2007; Reinehr et al., 2006; Walker et al., 2003; Yin et al., 2005). Despite the overwhelming benefits of such interventions, few have specifically examined their impact on African American adolescents. To date, the “FitKid Project,” (Yin et al., 2005) mentioned above, and the “GOGIRLS!” program are the only two interventions which have reported on primarily African American adolescent samples (Resnicow et al., 2000, 2005).
“GOGIRLS!” is a nutrition and physical activity intervention designed for inner-city, obese African American adolescents (Resnicow et al., 2000; Resnicow, Taylor, Basking, & McCarty, 2005). In the absence of a control group, researchers first examined the program’s effectiveness by comparing low and high attendees. Although Resnicow and colleagues (2000) concluded that high attendees showed more favorable outcomes on some variables, overall the groups varied very little psychosocially at post-testing. In 2005, Resnicow and colleagues assessed the outcomes of two similar interventions, one high-intensity and one moderate-intensity weight control intervention. Results paralleled their previous findings, again showing no significant between group differences in primary (i.e., BMI) or secondary outcomes (e.g., body fat percentage and cardiovascular fitness). In post-intervention focus groups, the most common obstacle reported by participants was lack of parental assistance with shopping and cooking (Resnicow et al., 2000). This suggests that the lack of direct family involvement was a limitation of this program. Evidence suggests that parents have a significant role in both the prevention and treatment of obesity in children and that positive parental role modeling and support are associated with increased physical activity in children (Zakarian, Hovell Hofstetter, Sallis, & Keating, 1994).

In addition to limited parental support (Resnicow et al., 2000), other studies with predominantly African American female samples have found that lack of peer support (Gray, Janicke, Ingerski, & Silverstein, 2008; Neumark-Sztainer, Story, Hannan, Tharp, & Rex, 2003), as well as perceived shortage of affordable, accessible, and culturally appropriate recreation facilities (Gordon-Larsen et al., 2004), are the most commonly
reported barriers to physical activity. Gray and colleagues (2008) concluded that youth who reported more barriers were less likely to participate in physical activity. Removal of these barriers might increase participation in physical activity in overweight, African American females. In conclusion, additional studies examining the physical activity patterns and quality of life of obese, African American female adolescents are warranted. Evaluations of family and peer-based interventions focused on the removal of culture-specific barriers facing the African American female population are also needed.

Recommendations for Best Treatment

In response to concerns that weight-loss interventions might do more psychological harm than good, the Expert Committee on childhood obesity treatment and evaluation has made several recommendations regarding safe and effective interventions (Barlow & Expert Committee, 2007). The committee recommends that the primary goal of obesity therapy should be small, gradual changes in healthy eating and physical activity. They note that rapid weight loss, or the achievement of an ideal weight, should not be encouraged. Further, it is recommended that treatment involve the child’s family or primary caretaker(s), who should be guided to facilitate gradual improvements in activity levels and food intake and who should be well educated about the medical and psychological complications of childhood obesity. To enhance success in a weight loss intervention, program visits should be frequent and reinforcement and monitoring should be continuous. Ideally, the combination of the above factors will result in the production and maintenance of positive behavioral changes. While pharmaceutical and surgical options exist for severely obese children, these methods are generally not recommended
as an alternative form of treatment, even when other programs have failed (Moran, 1999; Silber, Randolph, & Robbins, 1986; Uli, Sundararajan, & Cuttler, 2008).

Several programs have conformed to Barlow and the Expert Committee’s (2007) recommendations, but few have been critically evaluated. Of these few, it appears that interventions targeting both sedentary and active behaviors (Reinehr et al., 2006; Resnicow et al., 2000; Yin et al., 2005) with high peer (Jelalian et al., 2006) and parental involvement (Golan, 2006) have been most successful. Further, research has shown that African American female adolescents are in the most need of assistance, as they experience the highest obesity prevalence rates, lowest levels of physical activity (Gordon-Larson, et al., 1999), and most severe weight-related complications (Rosenbloom et al., 1999). Interestingly, there have been very few published prevention or intervention studies working primarily with this population. Finally, evidence for the benefits of physical activity is overwhelming and includes decreased depressive symptomatology and higher levels of life satisfaction and happiness (Piko & Keresztes, 2006; Stubbe et al., 2007).

Thus, the purpose of this study was to address limitations in the research and to assess the link between physical activity, physical fitness, and psychological well-being among adolescent participants in the T.E.E.N.S. program. Psychological well-being was defined using measures of HRQOL (specifically, its social, school, emotional, and physical subscales), depression, and body dissatisfaction. Indicators of physical fitness included body fat percentage (BF), BMI, and cardiorespiratory fitness (VO2max). Physical
activity values were calculated as the sum of reported hours of moderate activity and vigorous activity in the seven previous days.

It was hypothesized that psychological well-being would increase over time (i.e., from Time 1 to Time 2). Second, it was hypothesized that psychological well-being would increase as a function of improvements in physical activity and physical fitness. Changes in psychological well-being due to race/ethnicity and gender were also explored, although no specific hypotheses about these variables were proposed.
Methods

This study evaluated data from the T.E.E.N.S. program, a culturally sensitive, multidisciplinary intervention targeting obese (BMI ≥ 95%) adolescents and their families. The intervention, which began in November 2003 at Virginia Commonwealth University Health Systems, focuses on three major components: nutrition, exercise, and behavior modification. Data for the current study were collected at baseline (prior to any treatment) and at the end of the first six months of the program. Although individuals are permitted to participate for up to two years, the current study only includes participants’ physical and psychosocial data for their first six months of the program.

Participants

Participants were primarily referred to T.E.E.N.S. by pediatricians or family medicine physicians. Other health care providers such as dietitians and nurses also provided referrals, as did family members and friends familiar with or directly involved in T.E.E.N.S. Obese adolescent males and females between 11 and 18 years of age with a BMI ≥ 95th percentile for age and gender according to the 2000 CDC Growth Charts (Kuczamarski et al., 2002) were eligible for study participation if they had a primary care physician and at least one adult in the household who committed to attending program meetings. Parent participation in the nutritional and behavioral components of the program was highly encouraged. Adherence to minimal attendance standards (70% compliance) was required for continued program participation.
To date, over 280 adolescents have enrolled in T.E.E.N.S. Due to intermittent modifications in cardiorespiratory assessments, only those individuals in the third cohort (i.e., third wave of 100 participants) were included in this study for consistency purposes. Therefore, this study’s sample, at baseline, included 98 adolescents between the ages of 11 and 18 ($M = 13.66, SD = 1.83$). Thirty two participants remained at six months ($M = 13.84, SD = 1.72$). Thus, 32.65% of participants completed six months of the T.E.E.N.S. intervention. Although participants were not billed for the program, insurance status was obtained as a proxy for socioeconomic status (SES). Approximately one third of the total T.E.E.N.S. sample has Medicaid or are uninsured, findings consistent with the lower SES population generally seen at this urban medical center. Racial/ethnic and gender composition of the sample are presented in Table 1.

Table 1

*Characteristics of the study sample at baseline and post-test*

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Post-test</th>
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<td>N</td>
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<tr>
<td>Gender</td>
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<tr>
<td>Male</td>
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<td>31.60</td>
</tr>
<tr>
<td>Female</td>
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<td>68.40</td>
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<tr>
<td>Race/ethnicity</td>
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<td>Caucasian/White</td>
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<td>12.20</td>
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<tr>
<td>African American</td>
<td>81.00</td>
<td>82.70</td>
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<tr>
<td>Other</td>
<td>5.00</td>
<td>5.10</td>
</tr>
</tbody>
</table>
Participants meeting any of the following criteria were not eligible for study participation: underlying genetic, neurological, endocrine, or metabolic condition that preclude weight loss with conventional diet and exercise programs (e.g., Prader-Willi, Cushing’s syndrome, etc.), weight greater than 400 lbs., pregnancy in female adolescent participants during any point of the protocol, inability to understand program instructions due to language barrier or a mental disability, inability to participate in the outlined exercise program due to a physical disability, or primary residence outside a 30 mile radius of downtown Richmond, Virginia.

Measures

Demographic Questionnaire. This questionnaire was created by the researchers and asked participants to provide their age, year in school, race/ethnicity, gender, and current living situation.

Multidimensional Body-Self Relations Questionnaire—Appearance Evaluation Subscale (MBSRQ-AE). The Appearance Evaluation Subscale of the Multidimensional Body-Self Relations Questionnaire is a 7-item scale used to assess body dissatisfaction (Cash, 1994). Participants were asked to indicate the extent to which each of the seven statements applied to them. Responses ranged from 1 (definitely disagree) to 5 (definitely agree) and higher scores indicate greater satisfaction with appearance. Following the instructions in the measure’s manual, items 6 and 7 were reverse coded prior to obtaining each participant’s final total score (i.e., mean of the answers; Cash, 1994). In previous research conducted with a large adolescent population (N = 363) the temporal stability (4-
5 week) of the MBSRQ-AE was .89; this subscale also yielded internally consistent scores (α = .76; Banasiak et al., 2001). Cronbach’s alpha in the current study was .77.

Child Depression Inventory (CDI). Depression was assessed using the Children’s Depression Inventory (Kovacs, 1992). The CDI is a 27-item self-report symptom-orientated scale suitable for school-aged children and adolescents. For each item, the adolescent was asked to endorse one of three statements that best describe how he or she felt on average over the past two weeks. Each response is scored as 0 (asymptomatic), 1 (somewhat symptomatic), or 2 (clinically symptomatic), contributing to a total CDI score that can range from 0–54.

This measure has been found to yield internally consistent scores (α = 0.86, Ivarsson, Svalander, & Litlere 2006) and has demonstrated acceptable temporal stability when used in short-term intervals (i.e., 2 to 4 weeks; Kovacs, 1992; Sitarenios & Kovacs, 1999). The CDI has been found to effectively differentiate between clinical and community youth (Carey, Faulstick, Gresham, Ruggiero, & Enyart, 1987), as well as depressed and non-depressed children (Liss, Phares, & Liljequist, 2001), thus providing evidence for the scale’s construct validity. Timbremont, Braet, and Dreesson (2004) provided evidence for the scale’s criterion-related validity. Specifically, in a sample of children and adolescents, the CDI total score was predictive of a depressive disorder. The CDI has been utilized with White, African American, and Hispanic/Latino adolescents (however, no alphas were reported; e.g., Hayward, Gotlib, Schraedley, & Litt, 1999; Zeller & Modi, 2006). Cronbach’s alpha in the current sample was .88.
Pediatric Health-Related Quality of Life (PedsQL4.0). The Pediatric Health-Related Quality of Life (PedsQL4.0) measure has been widely used with children and adolescents, 2 to 18 years old, with and without chronic illnesses (Varni et al., 2003). It is a self-report scale consisting of 23-items assessing physical (8 items; Peds Physical), emotional (5 items; Peds Emotional), social (5 items; Peds Social), and school functioning (5 items; Peds School). The instructions ask how much of a problem each item has been during the last month. Items are reverse-scored and linearly transformed to a 0 – 100 scale (0=100, 1=75, 2=50, 3=25, 4=0), so that higher scores indicate better HRQOL (Pinhas-Hamiel et al., 2006).

The PedsQL4.0 has been found to discriminate effectively between healthy children and those with health problems (Varni, Seid, & Kurtin, 2001; Varni, Burwinkle, & Seid, 2006). Estimated internal consistency was greater than or equal to 0.86 for children ages 5 to 16 (Varni, Limbers, & Burwinkle, 2007). In an ethnically diverse sample of children and adolescents, the PedsQL4.0 measure surpassed the recommended minimum alpha coefficient for group comparisons (i.e., 0.70) and approached the minimum for individual analyses (i.e., 0.90; Varni et al., 2006). It also significantly distinguished healthy children from those with chronic health problems, thus demonstrating acceptable construct validity. Cronbach’s alphas in the current study were as follows: 0.81 (social functioning), 0.75 (physical functioning), 0.68 (emotional functioning), and 0.70 (school functioning).

7-day Physical Activity Recall (PAR). The 7-day PAR is one of the most widely used self-report measures of physical activity (Sallis, McKenzie, & Alcaraz, 1993a). The PAR
asks respondents to report the amount of time they spent in sleep, moderate, hard, and very hard activities during the previous seven days in 10 minute increments. Physical activity scores were calculated as the sum of reported minutes of moderate activity and vigorous activity, which includes time spent in hard and very hard activity. Time spent in each category was rounded to the nearest .25 hours as suggested in standard scoring procedures (Sallis et al., 1993a).

Previous research with the PAR using standardized interviewer protocol and training methods have produced same-day reliabilities across interviewers of .86 (Gross, Sallis, Buono, Roby, & Nelson, 1990). In a sample of 102 adolescents (White = 70, African American = 8, Latino = 10, Asian =11, Other = 3), the 2-week temporal stability coefficient was 0.77 (Sallis, Buono, Roby, Micale, & Nelson, 1993b).

Cardiorespiratory Fitness ($VO_{2\text{max}}$). Cardiorespiratory fitness was assessed via oxygen consumption during a maximal effort graded treadmill test. The progressive treadmill protocol consisted of a four minute warm-up at 2.0 mph and 0% grade followed by two 2 minute stages at 2.5 mph and 3.0 mph at 0% grade. Subsequent 2 minute stages were held constant at 3.0 mph while grade was increased to 2.0, 5.0, 8.0, 11.0, 14.0 and 17.0%. Heart rate response was monitored continuously during the test (Accurex IIa, Polar Electro, Inc., Lake Success, NY). Participants maintained the required work rates until they were unable to keep pace with the treadmill. Verbal encouragement was offered during the test. Continuous breath-by-breath oxygen consumption values were obtained (Vmax Spectra 29s, Sensormedics, Yorba Linda, California) and subsequently averaged over 20 seconds. Peak oxygen consumption ($VO_{2\text{max}}$) was determined as the
highest 20 second averaged oxygen consumption. Secondary criteria for VO$_{2\text{max}}$ included at least 2 of the following: maximal heart rate > 95% of age-predicted heart rate maximum, respiratory exchange ratio > 1.1, or a rating of perceived exertion > 18, from a scale of 6 (not hard at all) to 20 (the hardest imaginable).

To ascertain a value for VO$_{2\text{max}}$, weight (in kg) was measured and included in the denominator of its calculations. Subsequently, reductions in weight could have led to the appearance of increased VO$_{2\text{max}}$. In the current sample it was expected that participants’ height would increase, as the majority of the sample is still growing. This growth was expected to occur even in the presence of weight loss. Thus, to control for the impact of changes in weight, absolute, and lean mass VO$_2$ values were also calculated.

**Percent Body Fat (BF).** Percent body fat was determined by bioelectric impedance analysis (Quantum II Biolectrical Impedance Analyzer, RJL Systems, Clinton Twp., MI).

**Anthropometric measures.** Height was measured to the nearest 1/8 inch using a stadiometer. Weight was measured to the nearest 1/4 lb. using a medical balance beam scale. These data were used to calculate BMI and plotted on the CDC Growth Charts (Kuczamarski et al., 2002) to obtain BMI percentile for age and gender.

**T.E.E.N.S. Intervention**

All T.E.E.N.S. activities take place onsite at a location close to Virginia Commonwealth University’s (VCU) Monroe Park campus. Prior to enrolling in the T.E.E.N.S. intervention (i.e., at baseline), each family was required to complete a number of nutritional and behavioral questionnaires, laboratory work,
physiological/anthropometric measures, and a complete medical history and physical examination. Prospective participants identified as having potential health problems requiring further evaluation were referred to their pediatrician for testing or specialty referral. Assessments were repeated after six months of program enrollment.

Consent for the parents and assent for the adolescents were obtained in person by study staff. At the clinic baseline visit, participants established set goals of diet and exercise and developed their individualized treatment plans. A contract among the adolescent, his or her family, and the treatment team was developed for the following two weeks, which was then revised during each subsequent visit. As part of the protocol, each adolescent and his or her parent participated in a multidisciplinary program, which included exercise, nutrition and behavioral components. These components are described in the following paragraphs.

*Exercise.* Participants were required to document participation in a minimum of three days/week (five days/week recommended) of 60 minutes of exercise. This recommendation of five days/week is consistent with physical activity guidelines endorsed by the U.S. Department of Health and Human Services (USDHHS, 2005). Participation onsite, at the T.E.E.N.S. clinic, was required one day a week during which adolescents performed 30 minutes of cardiorespiratory fitness training (treadmill or cycle ergometer) followed by 30 minutes of resistance training. All participants and their parent or guardian were provided free memberships to a local YMCA location, a safe and convenient setting for them to complete the remaining two days of required exercise.
The exercise component of the program was designed to provide substantial energy expenditure during each training session. Therefore, the goal for each participant was to keep the exercise heart rate (HR) at or above 150 bpm, or 70-80% maximal HR, for 30 minutes each session. Each participant wore a Polar Pacer HR monitor during his or her first three exercise sessions to assess intensity (E600, Polar Electro Inc.). After the first three exercise sessions each participant wore the HR monitor at least once per week to determine an average exercise HR. After each session, the minute-by-minute HR data was downloaded into a computer for assessment and feedback to the participants.

Nutrition Education and Behavioral Support. Participants and parents/guardians rotated biweekly visits with the dietitian and behavior specialist. The dietitian measured participants’ height and weight at each visit, and conducted a 30 minute educational session during which the following topics were reviewed: the FDA Food Guide Pyramid, appropriate portion sizes, food labels, healthy snacking, and meal planning. Parents were required to attend each nutrition and behavioral specialist visit. Based on the assessment of the behavior specialist, the child was enrolled in either a support group consisting of same-gender participants or was asked to continue meeting with the behavior specialist for one-on-one sessions.

Statistical Procedures

SPSS 16.0 (Chicago, IL) was used for data entry and analyses. Six outcomes or dependent variables can be identified in the current study and are collectively referred to as psychological well-being. These variables include emotional, social, physical, and school functioning (i.e., PedsQL4.0), as well as depression (i.e., CDI) and body
dissatisfaction (i.e., MBSRQ-AE). The independent variables, or predictors, include continuous and categorical measures, namely: gender, race/ethnicity, physical activity, and indicators of physical fitness (BMI, BF and VO$_{2\text{max}}$).

Descriptive statistics, including frequencies, percentages, means and standard deviations, were generated to describe the sample. Independent samples t-tests identified significant differences between participants who completed post-testing and those who did not. Paired samples t-tests were used to explore significant changes in physical activity and physical fitness from baseline to post-testing. Pearson correlations were used to examine the associations among study variables for the total sample. To test the first and second hypotheses, several multilevel level model (MLM) analyses were performed for each outcome variable.

The current study examined a number of factors not previously explored in other obesity interventions with adolescent samples. Thus, one of the aims was to provide direction for future research efforts. Given the lack of previous work in this area effect sizes could not be determined ahead of time. Another factor affecting statistical power was that, for the cohort assessed, recruitment was limited to 100 participants. As a result, sample size was predetermined based on study protocol and was further limited by program attrition. Considering both the sample size and pilot nature of the data, all statistical tests were conducted using an alpha of .10 in order to protect against Type II error (Stevens, 1996).

MLMs are considered preferable to multiple regression models when researchers wish to investigate longitudinal outcomes (or growth curves) in a single group.
(Tabachnick & Fidell, 2007). In longitudinal designs, MLM provides a structure within which individual change can be analyzed independently and as a function of individual variables (Wu, 1996). More specifically, MLM is a technique capable of assessing nested variables, or those which are dependent on one another. When using multilevel linear models with repeated measures designs, the lowest level is the repeated observations of the individual. Thus, in the current study, the within groups variable entered into the first level of the model is time (coded as baseline = 0, 6 months = 1). In this case, time is a factor that can be described as a nested variable, as units of measurement are nested within the individuals themselves. Therefore, the first level represents individual change (or growth curve), and its direction, over time.

Covariates, including physical activity and indicators of physical fitness, were added separately to the model’s second level. The addition of these variables allowed for the assessment of “within-person fluctuations over time” (p. 872; Blackwell, Mendes de Leon, & Miller, 2006). All time-varying predictors in the second level were centered based on the grand mean. Grand mean centering can be used to relate each individual’s scores on Level 2 variables to deviations away from the average scores of the group (Blackwell et al., 2006). Centering techniques thereby enhance interpretation by producing a reference point for all outcomes based on a mean of 0.

At the third level, MLM permits examination of patterns of change among individuals and tests the contribution of subject-specific factors or characteristics to these patterns (Blackwell et al., 2006; Wu, 1996). Subject-specific factors identified as stable across time (e.g., gender and race/ethnicity) are entered separately into the third level of
the model. More specifically, in the current study, the addition of the third level allows for the examination of changes in psychological well-being as a function of gender (dummy coded female = 0, male = 1) and race/ethnicity after accounting for time and Level 2 covariates.

MLM models are preferred over alternative methods, such as analyses of variance, when using repeated measure designs because they address several common methodological limitations of longitudinal designs. For example, MLMs account for the correlation of individual observations and high variability among participants (Antretter et al., 2006; Tabachnick & Fidell, 2007). MLM designs also accommodate missing data and are capable of handling unequal groups. Further, it is important to note that analyses of variance were not feasible in the current study, given the single group design (i.e., there is no control group).

An additional advantage of MLM techniques, compared to traditional multiple regression models, is that they do not involve the use of change scores for the DVs and IVs of interest. For example, in traditional regression models, within-subject change scores would be computed for the fitness and activity measures by subtracting scores at Time 1 from scores at Time 2. Identical techniques would be used to compute within-subject change scores for each psychosocial DV. However, the use of change scores is controversial (Vickers & Altman, 2001), as these scores only account for the difference between Time 1 and Time 2 and are therefore restricted by ceiling and floor effects. For example, the change scores of some participants could appear larger because their extreme scores at Time 1 had the potential for more substantial change (e.g. regression to
the mean). Thus, change scores might not be an accurate representation of participant modifications, nor are they possible to compute with missing data.

Fortunately, MLM techniques are adept at dealing with these limitations. More specifically, time-varying covariates (e.g., physical activity and physical fitness) are naturally included and analyzed in an MLM (O’Connell & McCoach, 2004). Further, when data are missing (a reality of longitudinal intervention designs) it becomes impossible to compute change scores. A suboptimal solution might be dropping participants with incomplete observation sets. Fortunately, as noted previously, missing data are not a barrier to completing MLM analyses.

Moreover, SPSS programs have become capable of easily computing multilevel models (O’Connell & McCoach, 2004). Finally, single MLMs posses the ability to assess several between and within subject factors that have the potential to affect individual growth curves. By accounting for both within and between individual characteristics (versus only between in linear regression models), the analyses become more powerful, the error term is reduced, and “more accurate estimates of associations between predictor and outcome variables” are possible (p.872; Blackwell et al., 2006). However, one noteworthy limitation of multilevel models is the inability to utilize correlated predictors.

Prior to entering this study’s predictors into the model, it was important to ensure that MLM is appropriate for the data. This was assessed using an Intercepts-Only model. In this type of model, if the intercept variance is significant this means that there is sufficient variance among the participants, and MLM is appropriate. The significance of the Intercepts-Only model can be determined by examining estimates of covariance.
parameters. It is important to note that the reported \( p \)-value must be halved to reflect the one-tailed test of the intercept variance; (SPSS conducts only two-tailed tests for variance). Estimates of fixed effects were then be used to determine the significance of the Level 1 predictor (time). In other words, did changes in time (i.e., from baseline to post-testing) predict changes in outcomes? Random effects cannot be analyzed in models with two data collection points and thus were not calculated.

Level 2 analyses reflect whether the changes in the outcome variables were a function of modifications in physical fitness and/or physical activity. Fixed effects were produced for each predictor (i.e., physical activity, \( \text{VO}_2\text{max} \), BMI, and BF). Using physical activity as an example, the fixed effects indicated the average effect of physical activity on psychological well-being. In other words, as physical activity increases one unit, did psychological well-being increase, decrease, or stay the same?

Level 3 analyses reflected whether the changes in the outcome variable were a function of between participant variables (i.e., gender and race/ethnicity). The estimates of fixed effects were used to determine whether the Level 3 predictors are significant. In other words, did race/ethnicity meaningfully predict psychological well-being after accounting for other covariates in the first and second level?

In sum, each level of the MLM independently addressed each proposed hypothesis. Outcomes of the first level of the model addressed the first hypothesis, that psychological well-being would improve over time. The second levels of the models addressed the study’s second hypothesis, that improvement in physical activity and fitness would predict positive changes in psychological well-being. Hypotheses were not
presented regarding the influence of race/ethnicity and gender on well-being. However, outcomes from the third level of the models were used to assess the potential for these between-group differences.
Results

Data Preparation

Data were first checked to ensure that no out-of-range values were entered. Next, missing data were evaluated. If participants were missing any single-item predictor (i.e., physical activity total, BMI, VO$_{2\text{max}}$, or BF), they were obviously excluded from analyses using these values. For measures utilizing multiple items to ascertain a total score (i.e., CDI and MBSRQ-AE), the sample’s item mean was imputed prior to calculating final scores (DiLalla & Dollinger, 2006). One person was missing more than half of the items for the MBSRQ-AE and was thus excluded from analyses utilizing this variable.

Following the directions of the developers of the PedsQL4.0 (Varni et al., 2003), scores on this measure were calculated as the mean of items answered. Thus, missing items were not problematic, and no scores were imputed for any missing values on this measure. The PedsQL4.0 authors further recommend excluding participants missing more than half of the scale’s items. In this sample, no participant met such criteria at either data collection point.

The assumptions of level of measurement, independence of observations, normality, homogeneity of variance, and linear relationships were checked and sufficiently met. Correlations were also conducted and suggested that the measures of physical activity and physical fitness were distinct (see Table 2) from one another and thus did not need to be modified (i.e., combined or reduced) prior to being entered in the models.
Table 2

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. BMI%</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2. BF</td>
<td>0.14</td>
<td></td>
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<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>3. PAR</td>
<td>0.02</td>
<td>* -0.24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>4. Vigorous Activity</td>
<td>0.12</td>
<td>* -0.27</td>
<td>** 0.60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>5. Moderate Activity</td>
<td>0.07</td>
<td>0.10</td>
<td>** 0.81</td>
<td>0.01</td>
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<td></td>
</tr>
<tr>
<td>6. VO2max</td>
<td>** -0.46</td>
<td>** -0.35</td>
<td>** 0.30</td>
<td>* 0.24</td>
<td>0.21</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>7. CDI</td>
<td>0.06</td>
<td>-0.03</td>
<td>-0.05</td>
<td>0.01</td>
<td>-0.07</td>
<td>-0.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Peds Social</td>
<td>-0.04</td>
<td>* 0.22</td>
<td>0.10</td>
<td>0.18</td>
<td>-0.01</td>
<td>-0.03</td>
<td>** -0.40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Peds Physical</td>
<td>-0.09</td>
<td>0.06</td>
<td>0.16</td>
<td>** 0.29</td>
<td>-0.01</td>
<td>0.13</td>
<td>** -0.35</td>
<td>** 0.56</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>10. Peds Emotional</td>
<td>0.09</td>
<td>-0.07</td>
<td>0.10</td>
<td>0.10</td>
<td>0.05</td>
<td>0.12</td>
<td>** -0.30</td>
<td>** 0.36</td>
<td>** 0.48</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Peds School</td>
<td>-0.05</td>
<td>0.03</td>
<td>0.09</td>
<td>0.04</td>
<td>0.09</td>
<td>0.05</td>
<td>** -0.22</td>
<td>* 0.23</td>
<td>* 0.25</td>
<td>** 0.32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. MBSRQ-AE</td>
<td>* 0.18</td>
<td>-0.13</td>
<td>* 0.23</td>
<td>0.22</td>
<td>0.13</td>
<td>-0.04</td>
<td>** -0.47</td>
<td>** 0.37</td>
<td>** 0.33</td>
<td>** 0.45</td>
<td>0.19</td>
<td></td>
</tr>
</tbody>
</table>

Note. BMI% = Body Mass Index; BF = Body Fat percentage; PAR = 7 Day Physical Activity Recall; Vigorous PAR = time spent in vigorous physical activity; Moderate PAR = time spent in moderate physical activity; VO2max = cardiorespiratory fitness; CDI = Children’s Depression Inventory; Peds Social = Pediatric Health-Related Quality of Life social subscale; Peds Physical = Pediatric Health-Related Quality of Life physical subscale; Peds Emotional = Pediatric Health-Related Quality of Life emotion subscale; Peds School = Pediatric Health-Related Quality of Life school subscale; MBSRQ-AE = Multidimensional Body-Self Relations Questionnaire—Appearance Evaluation Subscale

*p < .10. **p < .01
**Descriptive Statistics**

Frequencies of the various demographic characteristics of the sample were calculated (at baseline and 6 months) and are presented in Table 1. Of note, all tables include values for both females and males unless otherwise specified. Pearson correlations among continuous variables for the total sample are presented in Table 2. There were significant negative correlations at baseline between body fat percentage (BF) and both physical activity and VO\(_{2\text{max}}\). In other words, participants with higher body fat percentages reported lower physical activity totals and cardiorespiratory fitness. Moreover, participants who reported participating in more physical activity and/or vigorous activity (see Table 2) also had higher cardiorespiratory fitness. BMI and BF were not correlated. However, in contrast to what might be expected, BF was significantly and positively correlated with social functioning, suggesting those with greater percentages of fat reported enhanced social functioning.

Nearly all psychosocial measures were significantly correlated with one another. Specifically, depression scores were negatively correlated with other measures of psychological well-being, suggesting that those with higher depressive symptoms also demonstrated lower school, emotional, social, and physical functioning, as well as higher body dissatisfaction.

Baseline scores for participants who completed 6-month assessments and those who did not were compared via independent samples t-tests. Mean scores for both groups are presented in Table 3. No significant differences were observed for scores on body fat percentage, physical activity, body dissatisfaction, or the social, physical,
emotional, or school subscales of the PedsQL4.0. There were significant differences among completers and non-completers in BMI, CDI scores, and VO\textsubscript{2max} suggesting those participants who completed six months had better cardiorespiratory fitness, lower body mass and less depressive symptoms at baseline, compared to those who did not complete six months. Many of these differences are consistent with previous research which suggests that attrition is more likely among individuals who are more depressed (White et al., 2004), less fit (Gray et al., 2008), and heavier at baseline (Huang et al., 2007; Jelalian et al., 2006; Resnicow et al., 2005). Further examination of participants’ baseline depression scores revealed that 30 (approximately 32%) participants had CDI scores of $\geq13$ (indicative of probable depression, Kovacs, 1992) at baseline. Moreover, 22 (approximately 22%) participants reported having suicidal thoughts and/or desires.
Table 3

*Group Differences for Psychosocial Functioning, Physical and Physical Fitness between Participants Who Did and Did Not Complete 6 Months*

<table>
<thead>
<tr>
<th>Psychosocial Functioning</th>
<th>Completers</th>
<th>Non-Completers</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>M</td>
<td>SD</td>
<td>N</td>
</tr>
<tr>
<td>CDI</td>
<td>31</td>
<td>8.24</td>
<td>63</td>
</tr>
<tr>
<td>Peds Social</td>
<td>31</td>
<td>68.39</td>
<td>63</td>
</tr>
<tr>
<td>Peds Physical</td>
<td>31</td>
<td>74.78</td>
<td>63</td>
</tr>
<tr>
<td>Peds Emotional</td>
<td>31</td>
<td>64.35</td>
<td>63</td>
</tr>
<tr>
<td>Peds School</td>
<td>31</td>
<td>69.68</td>
<td>63</td>
</tr>
<tr>
<td>MBSRQ-AE</td>
<td>29</td>
<td>2.66</td>
<td>61</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Activity</th>
<th>Completers</th>
<th>Non-Completers</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>M</td>
<td>SD</td>
<td>N</td>
</tr>
<tr>
<td>PAR</td>
<td>30</td>
<td>3.58</td>
<td>54</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Physical Fitness</th>
<th>Completers</th>
<th>Non-Completers</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>M</td>
<td>SD</td>
<td>N</td>
</tr>
<tr>
<td>VO$_{2\text{max}}$</td>
<td>32</td>
<td>25.52</td>
<td>54</td>
</tr>
<tr>
<td>BF</td>
<td>32</td>
<td>44.71</td>
<td>66</td>
</tr>
<tr>
<td>BMI%</td>
<td>32</td>
<td>99.09</td>
<td>66</td>
</tr>
</tbody>
</table>

Note. CDI = Children’s Depression Inventory; Peds Social = Pediatric Health-Related Quality of Life social subscale; Peds Physical = Pediatric Health-Related Quality of Life physical subscale; Peds Emotional = Pediatric Health-Related Quality of Life emotion subscale; Peds School = Pediatric Health-Related Quality of Life school subscale; PAR = 7 Day Physical Activity Recall; VO$_{2\text{max}}$ = cardiorespiratory fitness; BF = Body Fat percentage; BMI% = Body Mass Index

*p < .10. **p < .01

Chi square tests were conducted to examine the relationship between program completion and demographic variables. Results of the first test suggest that the percentage of participants who completed the T.E.E.N.S. program did not differ by
gender, $\chi^2(1, N = 98) = 0.00, p = .955$. To examine the relationship between program completion and race/ethnicity, Fisher’s Exact Probability Test was conducted. Fisher’s Exact Test is common with small data sets and is typically used when at least one cell in a cross-tabulation table has an expected frequency of less than 5 (as was the situation in this case, Boslaugh, 2007). The relation between these variables was not significant ($p = .51$), suggesting that there was no association between race/ethnicity and likelihood of completing six month post-testing.

Given the variability in reported HRQOL scores for overweight and obese populations (Schwimmer et al., 2003; Williams et al., 2005), means and standard deviations of the current sample were calculated for comparison purposes. At baseline, mean PedsQL4.0 subscale scores for the current sample were slightly higher than those reported for obese youth seeking medical treatment and lower than those reported using population-based samples of overweight youth, normal weight children and adolescents, and those diagnosed with cancer (see Table 4 for all means and standards deviations, Schwimmer et al., 2003; Varni, Burwinkle, Katz, Meeske, & Dickinson, 2002; Williams et al, 2005; Zeller et al., 2006). At post-testing, the current sample’s scores surpass those of all previously mentioned groups, other than the healthy, normal weight population.
Table 4

PedsQL 4.0 scores of current sample compared to obese youth seeking medical care, obese population-based youth, healthy youth, and youth diagnosed with cancer

<table>
<thead>
<tr>
<th>PedsQL 4.0 Scales</th>
<th>Treatment (N = 106)</th>
<th>Population (N = 63)</th>
<th>Healthy (N = 157)</th>
<th>Cancer (N = 219)</th>
<th>TEENS baseline (N = 98)</th>
<th>TEENS post (N = 28)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Peds Physical</td>
<td>71.00</td>
<td>18.80</td>
<td>77.50</td>
<td>17.90</td>
<td>84.40</td>
<td>17.30</td>
</tr>
<tr>
<td>Peds Emotional</td>
<td>63.20</td>
<td>20.10</td>
<td>68.60</td>
<td>18.50</td>
<td>80.90</td>
<td>19.60</td>
</tr>
<tr>
<td>Peds Social</td>
<td>67.50</td>
<td>26.00</td>
<td>72.60</td>
<td>18.20</td>
<td>87.40</td>
<td>17.20</td>
</tr>
<tr>
<td>Peds School</td>
<td>64.10</td>
<td>20.40</td>
<td>75.00</td>
<td>14.50</td>
<td>78.60</td>
<td>20.50</td>
</tr>
</tbody>
</table>

Information adapted from:
Obese Youth Seeking Medical Care (i.e., Treatment; Schwimmer et al., 2003; m = 12.1)
Obese, Population-Based Youth (i.e., Population; Williams et al., 2005; m = 10.4)
Healthy Youth (i.e., Healthy, Varri et al., 2002; m = 13.7)
Youth Diagnosed with Cancer (i.e., Cancer; Varri et al., 2002; m = 10.9)
All samples included boys and girls.

Note. Peds Social = Pediatric Health-Related Quality of Life social subscale; Peds Physical = Pediatric Health-Related Quality of Life physical subscale; Peds Emotional = Pediatric Health-Related Quality of Life emotion subscale; Peds School = Pediatric Health-Related Quality of Life school subscale

*p < .10. **p < .01
Primary Analyses

Analysis of the intercepts-only model with a compound symmetry covariate type suggested that there was significant variability in each DV. This finding suggested that it would be worthwhile to examine a conditional model that could potentially explain some of this variability. Refer to Table 5 for intercepts-only model statistics.

Table 5

Effects of Time, Physical Activity, and Physical Fitness on Psychosocial Functioning

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Predictor</th>
<th>F(df)</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td></td>
<td>173.68(91.59)</td>
<td>0.000</td>
</tr>
<tr>
<td>Level 1</td>
<td>Time</td>
<td>0.88(30.28)</td>
<td>0.357</td>
</tr>
<tr>
<td>Level 2</td>
<td>VO$_{2\text{max}}$</td>
<td>2.94(102.62)</td>
<td>0.089</td>
</tr>
<tr>
<td>Peds Social</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td></td>
<td>1299.17(97.63)</td>
<td>0.000</td>
</tr>
<tr>
<td>Level 1</td>
<td>Time</td>
<td>9.70(38.61)</td>
<td>0.003</td>
</tr>
<tr>
<td>Level 2</td>
<td>BF</td>
<td>3.80(100.74)</td>
<td>0.054</td>
</tr>
<tr>
<td>Peds Physical</td>
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<td></td>
</tr>
<tr>
<td>Intercept</td>
<td></td>
<td>2269.75(87.20)</td>
<td>0.000</td>
</tr>
<tr>
<td>Level 1</td>
<td>Time</td>
<td>3.39(41.34)</td>
<td>0.073</td>
</tr>
<tr>
<td>Level 2</td>
<td>VO$_{2\text{max}}$</td>
<td>2.85(101.87)</td>
<td>0.094</td>
</tr>
<tr>
<td></td>
<td>PAR</td>
<td>3.16(101.91)</td>
<td>0.078</td>
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<tr>
<td>Combined</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>VO$_{2\text{max}}$</td>
<td>1.34(89.30)</td>
<td>0.250</td>
</tr>
<tr>
<td></td>
<td>PAR</td>
<td>5.77(89.60)</td>
<td>0.018</td>
</tr>
<tr>
<td>Peds Emotional</td>
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<td></td>
</tr>
<tr>
<td>Intercept</td>
<td></td>
<td>1187.16(90.93)</td>
<td>0.000</td>
</tr>
<tr>
<td>Level 1</td>
<td>Time</td>
<td>5.49(33.69)</td>
<td>0.025</td>
</tr>
<tr>
<td>Level 2</td>
<td>VO$_{2\text{max}}$</td>
<td>7.08(103.36)</td>
<td>0.009</td>
</tr>
<tr>
<td></td>
<td>Intercept</td>
<td>Time</td>
<td>PAR</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------</td>
<td>-------------</td>
<td>-------------</td>
</tr>
<tr>
<td><strong>Peds School</strong></td>
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<tr>
<td>Intercept</td>
<td>1093.09</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Level 1</td>
<td>2.22(30.32)</td>
<td>0.146</td>
<td></td>
</tr>
<tr>
<td>Level 2</td>
<td>3.29(94.64)</td>
<td>0.073</td>
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<tr>
<td><strong>MBSRQ-AE</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>1158.00</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Level 1</td>
<td>6.74(46.06)</td>
<td>0.013</td>
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</tr>
<tr>
<td>Level 2</td>
<td>3.78(99.85)</td>
<td>0.055</td>
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<tr>
<td>Level 3</td>
<td>3.72(97.99)</td>
<td>0.057</td>
<td></td>
</tr>
</tbody>
</table>

*Note. Peds Social = Pediatric Health-Related Quality of Life social subscale; Peds Physical = Pediatric Health-Related Quality of Life physical subscale; Peds Emotional = Pediatric Health-Related Quality of Life emotion subscale; Peds School = Pediatric Health-Related Quality of Life school subscale; MBSRQ-AE = Multidimensional Body-Self Relations Questionnaire—Appearance Evaluation Subscale; PAR = 7 Day Physical Activity Recall; VO2max = cardiorespiratory fitness; BF = Body Fat percentage

*p < .10. **p < .01; Only significant Level 2 and Level 3 model estimates are reported

**Level 1.** MLM, Level 1 analyses evaluated the impact of the intervention on participants’ psychosocial outcomes (i.e., hypothesis 1). As Table 5 indicates, time was a significant predictor of changes in social functioning, physical functioning, emotional functioning, and body dissatisfaction. In other words, as time passed (i.e., increased from Time 1 to Time 2), social, physical and emotional functioning increased significantly, while body dissatisfaction decreased. Time was not a significant predictor of changes in depression scores or school functioning. Table 6 presents the parameter estimates for Level 1 fixed effects.
Table 6

*Level 1 Estimates of Fixed Effects*

<table>
<thead>
<tr>
<th>Outcome and Predictor</th>
<th>Baseline M(SD)</th>
<th>N</th>
<th>6 Months M(SD)</th>
<th>N</th>
<th>Estimate (95% CI)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDI</td>
<td>10.16(7.62)</td>
<td>94</td>
<td>7.36(0.80)</td>
<td>28</td>
<td>-0.96(-3.05-1.13)</td>
<td>1.02</td>
</tr>
<tr>
<td>Peds Social</td>
<td>73.09(21.21)</td>
<td>94</td>
<td>78.93(21.23)</td>
<td>28</td>
<td>** 9.02(3.06-14.89)</td>
<td>2.90</td>
</tr>
<tr>
<td>Peds Physical</td>
<td>74.46(16.43)</td>
<td>94</td>
<td>80.47(14.77)</td>
<td>28</td>
<td>* 5.36(-0.52-11.23)</td>
<td>2.91</td>
</tr>
<tr>
<td>Peds Emotional</td>
<td>64.20(19.12)</td>
<td>94</td>
<td>73.04(16.74)</td>
<td>28</td>
<td>* 6.67(0.88-12.46)</td>
<td>2.85</td>
</tr>
<tr>
<td>Peds School</td>
<td>68.28(20.20)</td>
<td>94</td>
<td>74.46(20.74)</td>
<td>28</td>
<td>3.79(-1.40-8.98)</td>
<td>2.54</td>
</tr>
<tr>
<td>MBSRQ-AE</td>
<td>2.59(0.80)</td>
<td>90</td>
<td>3.05(0.69)</td>
<td>28</td>
<td>* 0.38(0.09-0.68)</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Note. CDI = Children’s Depression Inventory; Peds Social = Pediatric Health-Related Quality of Life social subscale; Peds Physical = Pediatric Health-Related Quality of Life physical subscale; Peds Emotional = Pediatric Health-Related Quality of Life emotion subscale; Peds School = Pediatric Health-Related Quality of Life school subscale; MBSRQ-AE = Multidimensional Body-Self Relations Questionnaire—Appearance Evaluation Subscale

*p < .10. **p < .01
Changes in physical activity and fitness were also assessed via paired samples t-tests. From baseline to six months, there were statistically significant decreases in body mass and body fat percentage and increases in cardiorespiratory fitness. As was noted in the Measures section, because: 1) weight is included in the calculations for VO$_{2\text{max}}$ and 2) participants’ height significantly increased while their weight significantly decreased during the course of the intervention, absolute and lean mass VO$_2$ values were also calculated to control for the impact of changes in weight. Results showed that there were significant increases in both absolute and lean mass VO$_2$. Vigorous activity also significantly increased although no significant changes were noted in moderate activity. Refer to Table 7 for means and standard deviations.
Table 7

*Changes from baseline to post-testing in physical activity and physical fitness*

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Post-test</th>
<th>df</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Physical Activity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAR</td>
<td>3.53</td>
<td>3.84</td>
<td>4.50</td>
<td>3.54</td>
</tr>
<tr>
<td>Vigorous PAR</td>
<td>1.02</td>
<td>1.63</td>
<td>2.32</td>
<td>2.53</td>
</tr>
<tr>
<td>Moderate PAR</td>
<td>2.48</td>
<td>3.37</td>
<td>2.18</td>
<td>1.90</td>
</tr>
<tr>
<td>Physical Fitness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VO&lt;sub&gt;2max&lt;/sub&gt;</td>
<td>25.52</td>
<td>5.01</td>
<td>28.45</td>
<td>6.03</td>
</tr>
<tr>
<td>VO&lt;sub&gt;2lean&lt;/sub&gt;</td>
<td>45.59</td>
<td>9.99</td>
<td>50.90</td>
<td>8.17</td>
</tr>
<tr>
<td>VO&lt;sub&gt;2abs&lt;/sub&gt;</td>
<td>2.38</td>
<td>0.50</td>
<td>2.70</td>
<td>0.57</td>
</tr>
<tr>
<td>BF</td>
<td>44.53</td>
<td>11.02</td>
<td>43.20</td>
<td>11.38</td>
</tr>
<tr>
<td>BMI%</td>
<td>99.09</td>
<td>0.73</td>
<td>98.52</td>
<td>1.35</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height (cm)</td>
<td>163.96</td>
<td>9.07</td>
<td>165.03</td>
<td>8.69</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>101.29</td>
<td>22.13</td>
<td>97.45</td>
<td>21.64</td>
</tr>
</tbody>
</table>

Note. PAR = 7 Day Physical Activity Recall; Vigorous PAR = time spent in vigorous physical activity; Moderate PAR = time spent in moderate physical activity; VO<sub>2max</sub> = cardiorespiratory fitness; VO<sub>2lean</sub> = lean mass cardiorespiratory fitness; VO<sub>2abs</sub> = absolute cardiorespiratory fitness; BF = Body Fat percentage; BMI% = Body Mass Index

*p < .10. **p < .01

*Level 2. The second level of each model examined the second hypothesis, that increases in physical activity and indicators of physical fitness would predict improvements in each psychosocial outcome. As Table 5 indicates, increases in cardiorespiratory fitness predicted decreases in depression, and improvements in school,
physical, emotional, and functioning. Moreover, as physical activity increased, physical functioning and body dissatisfaction also improved. Finally, contrary to what might be expected, increases in body fat percentage predicted enhanced social functioning.

Physical activity and VO$_{2\text{max}}$ were entered in the same model for physical functioning. In this model, the predictive power of physical activity remained significant however VO$_{2\text{max}}$ was rendered insignificant, suggesting that physical activity is predictive of physical functioning above and beyond VO$_{2\text{max}}$ (i.e., accounts for more variance). Nonetheless, the model that included both physical activity and VO$_{2\text{max}}$ explained significantly more variance than did the models that included only physical activity or VO$_{2\text{max}}$. Specifically, likelihood ratio Chi-squares indicated that the change in -2 restricted log likelihood of 100.66 ($df = 1$), $p<.01$ (physical activity only model) and 117.65 ($df = 1$), $p<.01$ (VO$_{2\text{max}}$ only model) were significant. All other possible relationships between the study’s predictors and outcomes were non-significant.

Previous studies suggest that different levels of physical activity (i.e., vigorous versus moderate physical activity) might be differentially associated with psychological well-being (Crews et al., 2004; Stella et al., 2005). To test this hypothesis, three separate MLM models were evaluated, one with total physical activity, a second with only vigorous activity, and a third with only moderate activity. Results indicated that both total physical activity and vigorous activity only significantly predicted improvements in physical functioning and body dissatisfaction. Moderate physical activity was not associated with any changes in psychological well-being. Table 8 presents the parameter estimates for level 2 fixed effects.
Table 8

*Significant Level 2 and 3 estimates of fixed effects*

<table>
<thead>
<tr>
<th>Outcome Predictor</th>
<th>Estimate</th>
<th>SE</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VO\textsubscript{2max}</td>
<td>* -0.24</td>
<td>0.14</td>
<td>-0.51</td>
<td>0.04</td>
</tr>
<tr>
<td>Peds Social</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BF</td>
<td>* 0.35</td>
<td>0.18</td>
<td>-0.01</td>
<td>0.70</td>
</tr>
<tr>
<td>Peds Physical</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAR</td>
<td>* 0.69</td>
<td>0.39</td>
<td>-0.08</td>
<td>1.45</td>
</tr>
<tr>
<td>Vigorous PAR</td>
<td>** 1.70</td>
<td>0.59</td>
<td>0.54</td>
<td>2.86</td>
</tr>
<tr>
<td>VO\textsubscript{2max}</td>
<td>* 0.50</td>
<td>0.30</td>
<td>-0.09</td>
<td>1.09</td>
</tr>
<tr>
<td>Peds Emotional</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VO\textsubscript{2max}</td>
<td>** 0.93</td>
<td>0.35</td>
<td>0.24</td>
<td>1.63</td>
</tr>
<tr>
<td>Peds School</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VO\textsubscript{2max}</td>
<td>* 0.65</td>
<td>0.36</td>
<td>-0.06</td>
<td>1.36</td>
</tr>
<tr>
<td>MBSRQ-AE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAR</td>
<td>* 0.04</td>
<td>0.02</td>
<td>0.00</td>
<td>0.07</td>
</tr>
<tr>
<td>Vigorous PAR</td>
<td>* 0.05</td>
<td>0.03</td>
<td>0.00</td>
<td>0.11</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>†White/African American</td>
<td>** -0.64</td>
<td>0.22</td>
<td>-1.08</td>
<td>-0.19</td>
</tr>
</tbody>
</table>

†Values associated with estimates using African Americans as the comparison group

Note. CDI = Children’s Depression Inventory; Peds Social = Pediatric Health-Related Quality of Life social subscale; Peds Physical = Pediatric Health-Related Quality of Life physical subscale; Peds Emotional = Pediatric Health-Related Quality of Life emotion subscale; Peds School = Pediatric Health-Related Quality of Life school subscale; MBSRQ-AE = Multidimensional Body-Self Relations Questionnaire—Appearance Evaluation Subscale; PAR = 7 Day Physical Activity Recall; Vigorous PAR = time spent in vigorous physical activity; VO\textsubscript{2max} = cardiorespiratory fitness; BF = Body Fat percentage

*p < .10. **p < .01
Level 3. The third level examined whether gender or race/ethnicity significantly influenced psychological well-being outcomes in this sample. Therefore, gender and race/ethnicity were added separately to each significant Level 2 model. The only model in which race/ethnicity was significant was the one which included physical activity (predictor) and body dissatisfaction (outcomes). As Table 5 indicates, both physical activity and race/ethnicity were independent predictors of body dissatisfaction although their interaction was not significant ($F(2, 87.35) = 0.02, p=0.981$). These findings suggest that White participants ($M=2.05$, $SD=0.63$; $M=2.65$, $SD=0.94$) endorsed higher body dissatisfaction than did African American participants ($M=2.69$, $SD=0.81$; $M=3.15$, $SD=0.67$) at both baseline and post-testing, respectively. The model that included both physical activity and race/ethnicity explained significantly more variance than did the model that only included physical activity. Specifically, a likelihood ratio Chi-square indicated that the change in -2 restricted log likelihood of 6.34 ($df = 2$) was significant, $p<.05$. Table 8 presents the parameter estimates for level 3 fixed effects. Please refer to Appendix A for a list of all models evaluated in the current study.
Discussion

Research overwhelmingly supports the link between physical activity and psychosocial well-being in youth and adults (Crew, et al., 2004; Faigenbaum, 2000; Farmer et al., 1988; Kirkaldy et al., 2002; McAuley et al., 1997; Motl et al., 2004; Mutrie & Parfitt, 1998; Sagatun et al., 2007; Shoup et al., 2008; Stella et al., 2005). More recently, markers of physical fitness, such as cardiorespiratory fitness, have also been linked to improvements in psychological health in youth populations (see Ortega et al., 2008 for a review). The benefits associated with exercise may be particularly important for obese adolescents as they are prone to high levels of inactivity (Saelens, 2003) and poor psychological well-being (Hesketh et al., 2004; Schwimmer et al., 2003; Walker et al., 2003). Moreover, several factors, including gender, race/ethnicity (Centers for Disease Control, 2006; Pate et al., 2002), BMI (Erermis et al., 2004; Vlierberghe et al., 2009; Williams et al., 2005), and treatment-seeking status (Braet et al., 1997; Britz et al., 2000; Pinhas-Hamiel et al., 2006; Wardle & Cook, 2005; Williams et al., 2005; Vlierberghe et al., 2009; Zeller & Modi, 2006), are associated with poor quality of life (see Tsiros et al., 2009 for a review) and low levels of activity in adolescents. Thus, research is needed to evaluate factors associated with changes in activity and quality of life, particularly in obese, treatment-seeking, African American girls.

To date, research examining this relationship among overweight and obese adolescents is scarce and restricted to cross-sectional designs (Shoup et al., 2008). The current study is the first to examine the longitudinal changes in physical activity, fitness,
and quality life in obese adolescents. Results were ascertained via multilevel modeling and suggest that participants in the T.E.E.N.S. obesity intervention demonstrated notable improvements in body dissatisfaction, as well as emotional, physical, and social functioning. Moreover, distinct aspects of physical activity and fitness were differentially related to significant enhancements in psychosocial health. Specifically, cardiorespiratory fitness was a powerful marker of depression and several domains of health-related quality of life. In addition, increases in total physical activity, as well as increases in vigorous activity, led to substantial improvements in body dissatisfaction and physical functioning. Moreover, in contrast to African American participants, White youth manifested higher body dissatisfaction over the course of treatment. Compared to cross-sectional research, outcomes from this longitudinal study provide more definitive evidence in support of the psychosocial benefits of physical activity and highlight the importance of detailed fitness assessment in future obesity interventions. The remainder of this Discussion reviews the results in greater detail, places them in the context of the previous literature, and summarizes their implications for future research.

Effects on Quality of Life and Depression

The improvements in social functioning (as measured by the PedsQL4.0) found in the current study might be the result of participants’ increased opportunities to have interpersonal experiences, such as time spent with other obese adolescents during the T.E.E.N.S. program (Walker et al., 2003). It has been suggested that these experiences may foster a sense of peer support, which has been linked to increased participation in
exercise (Anderson & Wold, 1992; Salvy et al., 2008a; Salvy et al., 2008b; Walker et al., 2003; Wardle & Cook, 2005).

It is also noteworthy that significant gains in emotional functioning were found among participants. As measured by the PedsQL4.0, emotional functioning encompasses several affective indicators of well-being, including fear, anger, sadness, and apprehension. Thus, this subscale assesses more normative emotional experiences than those which would likely be captured via a measure of depression, for example. This is important to note, as changes in depression were not found in this study. Finally, the notable improvements in physical functioning are likely attributable to participants’ increased involvement in healthy activity behaviors (e.g., gym workouts) over the course of the intervention.

Significant changes in school functioning were not found in the current study. It seems plausible that school functioning is strongly influenced by many other factors that were not specifically targeted or impacted by the T.E.E.N.S. intervention. For example, Cottrell, Northrup, and Wittberg (2007) found that obese children were more likely than their normal-weight peers to score poorly on standardized tests of mathematics, reading/language arts, and science. However, this relationship between weight status and academic performance was weakened after controlling for gender and socioeconomic status. In 2007, Judge and Jahns found that overweight girls were more likely than normal weight girls to exhibit poorer interpersonal skills, approaches to learning, and self-control, as well as internalizing and externalizing symptoms. Similar associations
among behavioral problems and overweight status in girls were presented by Datar and Sturm in 2004.

Taken together, research suggests that overweight, African American females, such as those in the T.E.E.N.S. program, may be encountering a number of social and environmental barriers which can inhibit positive changes in academic functioning. Literature suggests that factors such as youths’ race/ethnicity, mother’s education level, sedentary behaviors, and SES, seem to be more strongly associated with measured academic performance than overweight status (Cottrell, et al., 2007; Datar, Sturm, & Magnabosco, 2004; Huang, Goran, & Spruijt-Metz, 2006). In sum, measurements of school functioning are influenced by a range of factors which extend well beyond weight status, and many of them (e.g., SES, mother’s education level) are not appropriate targets for a pediatric obesity intervention.

Although the general psychosocial well-being of T.E.E.N.S. participants improved, it is important to note the significant psychological issues manifested by this group. Examination of participants’ CDI scores at baseline (Kovacs, 1992) revealed that over 30% of T.E.E.N.S. participants presented with symptomatology suggestive of clinical depression. Moreover, approximately 22% of participants reported having thought about or attempted suicide. These values are comparable to those reported by other obese, treatment-seeking adolescents (Daley et al., 2006). Higher depression scores were also associated with increased attrition rates in the current study. Additionally, the current sample’s HRQOL, as mentioned previously, is lower than that of youth receiving cancer treatment (Schwimmer et al., 2003). It is therefore critical that future interventions
accurately evaluate and attend to the mental health correlates of pediatric obesity. Doing so will not only increase program retention, but will ensure that youth with more severe psychopathology are receiving the support they need. This seems especially important for severely depressed adolescents who may best be served by referral to the appropriate mental health professionals before entering into a pediatric obesity program, such as T.E.E.N.S.

Effects on Body Dissatisfaction

The significant reductions in body dissatisfaction found among participants in T.E.E.N.S. are particularly encouraging, given the characteristics of the current sample. T.E.E.N.S. participants were largely female and the average age of this sample was 13.7 years (i.e., mid-adolescence). Moreover, most had BMI values above the 98th percentile (Kuczamarski et al., 2002). Obese adolescent girls are susceptible to higher body dissatisfaction compared to normal weight youth and males (Huang et al., 2007; Israel & Isanovva, 2002; Kimm et al., 2002). Thus, it is particularly noteworthy that significant and positive changes in body image were found.

Summary of Psychosocial Effects

The psychosocial changes noted in the current sample replicate and extend previous literature examining the impact of obesity interventions on adolescents. Those in the Go Girl’s project (Resnicow et al., 2000), for example, a population that closely resembles that of the T.E.E.N.S. program, did not report improvements in exercise self-efficacy, self-esteem, emotional eating, or preoccupation with food or body image. However, it is important to note that, unlike the current study which utilized well-
validated measures of psychosocial functioning, Resnicow and colleagues (2000) created and administered many of their own questionnaires. Thus, their findings should be considered in light of their psychometric limitations.

In addition, Huang and colleagues (2007) also reported significant improvements in their sample’s body dissatisfaction, but only for those who maintained or reduced their weight. Walker et al. (2003) found that their intervention participants endorsed greater self-worth, athletic competence, physical appearance esteem, self-esteem, and body satisfaction. Jelalian and colleagues’ (2006) findings were similar (i.e., improvements in global self-concept, physical appearance, and physical self-worth). Those who participated in the T.E.E.N.S. program also noted positive changes in measures of physical functioning and body dissatisfaction. However, the current study is the only one of its kind to assess additional domains of psychological functioning (e.g., depression, social functioning, emotional functioning), most of which significantly improved over time.

Effects on Physical Activity and Physical Fitness

In addition to changes in psychological well-being, improvements in markers of physical fitness were also noted. From baseline to post-testing, participants exhibited reductions in BMI and body fat percentage, as well as improvements in cardiopulmonary fitness. Weight loss and height increases were also significant, indicating that the anthropometric changes reflect a true improvement in body composition, not just alterations in stature. Of note, significant increases in absolute VO₂ support the notion that participants truly enhanced their ability to use oxygen more efficiently. The changes
in cardiorespiratory fitness are particularly encouraging as research suggests higher
VO_{2\text{max}} may counteract many of the cardiovascular risk factors associated with elevated
adiposity (Ortega et al., 2008). These outcomes were noted despite the lack of significant
changes in total physical activity. However, participation in vigorous activity did increase
over time and was significantly and positively associated with VO_{2\text{max}} in the current
sample. These findings suggest that increased participation in vigorous activity may lead
to increases in cardiorespiratory fitness.

Other factors which might have influenced changes in VO_{2\text{max}} include exercise
self-efficacy and increased mobility. Although these variables were not specifically
measured in the current study, they should be considered in future research, as one
potential component of VO_{2\text{max}} testing is rating of perceived exertion. During the
cardiorespiratory fitness assessment, intensity of exercise on a treadmill continually
increases until a participant indicates a certain level of physical exertion. Improvements
in exercise self-efficacy, reportedly the strongest mediator of changes in physical activity
(Lubans, Foster, & Biddle, 2008), might contribute to participants’ beliefs that they can
perform at a greater intensity during their second graded exercise test (i.e., at six months).
Finally, reductions in overall body mass likely enhanced participants’ mobility, thus
enabling participants to achieve higher work rates during the graded exercise test.

**Associations between Physical Activity, Fitness and Psychosocial Well-Being**

The noted improvements in cardiorespiratory fitness were also associated with
several significant changes in psychological well-being. More specifically, increases in
VO_{2\text{max}} were related to improvements in depressive symptoms, as well as school,
emotional, physical, and psychosocial functioning. To my knowledge, no study has investigated the longitudinal relationships of these variables among obese adolescents. Therefore, exploration of results will be considered in light of cross-sectional outcomes and studies with older and normal weight populations.

**Depression.** Previous research has consistently identified a strong relationship between depression and physical activity (Mutrie & Parfitt, 1998; Stella et al., 2005). However, less is known about the impact of changes in fitness on depressive symptoms. In the current study, improvements in participants’ aerobic capacity were linked to reductions in their depressive symptomatology. This finding is consistent with previous correlational studies which found that youth who engage in vigorous activity also endorse both greater increases in VO$_{2\max}$ and decreases in depression compared to youth engaging in moderate physical activity (Crews et al., 2004).

Specifically, in one prior study with obese girls, participants enrolled in an aerobic exercise intervention demonstrated significant reductions in depressive symptoms at post-testing (Stella et al., 2005). However, Stella and colleagues did not find improvements in mood among youth in the anaerobic, leisure, or no activity conditions. Unfortunately, this previous study did not assess VO$_{2\max}$. Perhaps participation in more intense exercise indirectly impacted the participants’ affective symptoms through the likely increases in aerobic capacity. This hypothesis was supported in a second study, which demonstrated that normal weight youth who participated in an intense exercise intervention experienced significant decreases in depression scores and greater increases in cardiorespiratory fitness compared to those in a less physically intense control group.
(Crews et al., 2004). Taken together, results of both the current study and previous research suggest that activity might need to be vigorous in intensity (and thus, lead to larger improvements in VO$_{2 \text{max}}$), to impact depression significantly.

*Health-Related Quality of Life.* Increases in participants’ aerobic capacity were also associated with gains in several domains of HRQOL. This finding is promising because research suggests that obese, treatment-seeking adolescents suffer from low HRQOL (Schwimmer et al., 2003), especially when they engage in less activity than is recommended for their age (Shoup et al., 2008). Previous studies have not directly examined the relationship between increased aerobic capacity and enhanced emotional, physical, and school functioning. However, Janicke and colleagues (2007) have proposed that depression mediates the relationship between obesity and QOL. Janicke and colleagues’ theory might explain the current study’s findings of concurrent improvements in VO$_{2 \text{max}}$, depression, and domains of the PedsQL4.0. Moreover, current results are also consistent with those found in adult men; specifically, men who improved their cardiorespiratory fitness after a five month exercise intervention also manifested enhanced physical esteem (McAuley et al., 1997). In sum, current and prior findings suggest that individuals who become more confident in their body’s abilities might also become more confident in other domains of functioning (i.e., emotional, psychosocial, and school).

The only domain of HRQOL not associated with changes in physical fitness was social functioning. This finding is noteworthy because research consistently promotes the theory that peers serve as role models and support one another in improving physical
activity behaviors. Specifically, overweight children tend to work out longer and more intensely in the presence of peers and/or friends (Neumark-Stzainer et al., 2003; Salvy et al., 2008a and 2008b; Springer et al., 2006). It thus seems logical that social functioning would increase along with physical fitness. However, there is also research suggesting that overweight youth are less inclined to seek out the company and support of their overweight peers (Bell & Morgan, 2000). On the other hand, it is important not to over-interpret this finding, as the average participant reported significant improvements in both social functioning and cardiorespiratory fitness at post-testing. Still, this outcome provides evidence for the strength of the T.E.E.N.S.’s environment in promoting the development of its participants’ social development independent of changes in fitness or body composition.

Increased VO$_{2\text{max}}$ and physical activity were both associated with enhanced physical functioning as measured by the PedsQL4.0. These findings parallel those reported with adult populations (McAuley et al., 1997). It is feasible that, among T.E.E.N.S. participants, exercising on a regular basis provided an increased sense of mastery or achievement, thus increasing his or her perceived physical functioning. Moreover, T.E.E.N.S. participants’ increased engagement in vigorous activity and consequent improvements in cardiorespiratory fitness were likely associated with enhanced abilities to perform activities in their everyday lives (e.g., climbing up stairs or playing in gym class). Interestingly, increases in vigorous activity were also associated with enhanced physical functioning. This finding differs from those reported in prior studies (e.g., Goldfield et al., 2007), which found that lower intensity exercises performed
for longer periods of time might enhance participants’ physical self-efficacy and program adherence, more so than exercise intended to improve fitness (i.e., vigorous activity). In the current study, lower level activity was not significantly associated with physical functioning.

**Body Dissatisfaction.** Participants who engaged in more physical activity on a weekly basis reported more positive changes in body dissatisfaction compared to others in the current intervention. Prior research supports this beneficial relationship between physical activity and body image. For example, British adolescent girls enrolled in a six-week aerobic dance intervention reported significant reductions in “feeling fat” and increases in “attractiveness” compared to those enrolled in a physical activity instructional program (Burgess et al., 2006). Although Burgess et al.’s (2006) study recruited primarily individuals of normal weight, they targeted girls with low levels of physical activity, as well as poor attitudes about their body and physical abilities. Results may thus generalize to the current sample, as they are also apt to endorsing such qualities (Centers for Disease Control, 2006; Huang et al., 2007; Pate et al., 2002; Schwimmer et al., 2003; Walker et al., 2003).

However, the current study’s results also parallel previous research which posits that White adolescent girls are more susceptible to poor body image compared to African American adolescents (Huang et al., 2007; Young-Hyman et al., 2003). It has been suggested that African Americans endorse a larger body ideal and are thus less impacted by the stigmas associated with obesity (Padgett & Biro, 2003). These findings strongly speak to the rationale of the intervention. If overweight and obese African American
adolescents and their parents/caregivers are less aware of their weight status and associated complications, it is important that T.E.E.N.S. staff communicate the negative health consequences of pediatric obesity without promoting weight preoccupation or poor body image. Moreover, the differential reporting of body dissatisfaction may help guide staff when formulating treatment plans for varying races/ethnicities in the future.

Directions for Future Research

The exact mechanisms of psychosocial change resulting from enhanced cardiorespiratory fitness and physical activity are unknown. In the past, researchers have proposed that other positive changes, such as enhanced self-efficacy, increased autonomy, (Fox, 1999) and/or a sense of achievement (Crews et al., 2004) might strengthen the impact of increased activity and/or fitness. In fact, self-efficacy to be active (or increased confidence about the body and its capabilities) has been found to mediate the relationship between interventions and physical activity (Lubans et al., 2008).

It has been suggested that increases in self-efficacy might then generalize to other domains of well-being (Fox, 1999). Also, increased physical fitness (i.e., VO₂max) is often associated with reductions in body mass. Perhaps these changes are visible to others, who then provide the participant with positive feedback and praise, thereby enhancing his or her mood.

A review on the influence of physical activity on mental health (Fox, 1999) proposes several additional hypotheses. First, participation in physical activity and increased fitness (Ortega et al., 2008) improves the health of an individual, thereby indirectly reducing the affective symptoms associated with feeling sick or getting hurt.
Physical activity has also been associated with better sleep quality, which often lends to enhanced psychosocial well-being and cognitive functioning. People are also more likely to rate their mental health as higher after performing single bouts of exercise (i.e., the “exercise high” phenomenon or the “feeling good effect;” pp.412, 414). Finally, changes in the physiological function of the body (e.g., increased body core temperature, muscle relaxation, neurotransmitter efficiency) could also be linked to improved mood.

Although the means by which these changes occur are unknown, the current study supports and extends previous research by providing longitudinal evidence for the psychosocial benefits of exercise and improved fitness. Moreover, the current study’s findings suggest that positive changes in psychosocial well-being were unrelated to weight loss, changes in BMI, or reductions in body fat percentages. In previous studies, many of the psychosocial improvements noted were associated primarily with weight loss (Huang et al., 2007; Walker et al., 2003). The fact that psychosocial improvements were not directly associated with weight loss among T.E.E.N.S. participants reduces concern about the potential for negative affect associated with failing to meet weight loss goals (Cameron, 1999).

**Strengths and Limitations**

The current study has a number of strengths. First, it focused on African American adolescents. Treatment-seeking, African-American obese females (the majority of the current sample), are at higher risk for obesity-related complications and negative health behaviors compared to their male, White, and normal weight peers (Grunbaum et al., 2002; Karter et al., 1998; Kimm et al., 2002; Ogden et al., 2002 and 2006;
Rosenbloom et al., 1999; Thompson et al., 2007; Tsiros et al., 2009; Wadden et al., 1990). Despite their likelihood of experiencing long-term health and psychological complications, research examining the efficacy of obesity interventions with this population is scarce. Thus, the current study addresses a substantial gap in the pediatric obesity literature.

Moreover, most prior studies of physical activity levels in youth populations have utilized retrospective, self-report, single-item assessment tools (e.g., Motl et al., 2004; Sagatun et al., 2007). However, the current study assessed physical activity with a well-validated clinical interview questionnaire (Sallis et al., 1993a, 1993b). Parents/caregivers were permitted to assist their children when approximating time spent in physical activity. Participants were then asked to independently rate the intensity of their exercise. This multi-perspective approach may have further increased the reliability of the scale. Moreover, the average age of T.E.E.N.S. participants was approximately 13.7 years. The estimates of youth at this age are considered more accurate than younger children who are at an earlier stage of cognitive development (Evans, personal communication, March 23, 2009).

Still, the PAR is not without its limitations. It does not control for time of year (e.g., football season versus summer), which could contribute to significant variations in reported weekly physical activity between baseline and six months. It is also possible that participants became more accurate in self-reporting the duration and intensity of their physical activity over the course of the intervention. Although devices like accelerometers could provide more accurate measures of physical activity, these tools are
expensive and difficult to maintain. Nonetheless, future studies could consider use of accelerometers.

In addition, few prior studies have assessed long-term changes in physical fitness (i.e., cardiorespiratory fitness) among adolescents in a pediatric obesity intervention. Finally, the utilization of multilevel analyses afforded the opportunity to assess the relationship between changes in physical and psychosocial scores over time. The relationship between these variables has not been assessed in previous studies, particularly in treatment-seeking, obese youth.

Nonetheless, there are several limitations to the current study. First, a randomized controlled trial was not performed, as it was deemed unethical to withhold treatment from this high-risk group. The lack of control group makes it impossible to infer causal relationships among the study’s variables and thus limits the internal validity of the study. Therefore, it is impossible to tell whether changes in psychological well-being are the result of time (and associated developmental changes), program participation, or true modifications in health behavior. It is also plausible that changes in the outcomes led to changes in the predictors (e.g., participants who experienced reductions in their depression found it easier to engage in physical activity to the point of improving their cardiorespiratory fitness). Moreover, assessment of the long-term feasibility and efficacy of the T.E.E.N.S. program was limited as the outcomes were based on two time points assessed over the course of six months.

Furthermore, the current sample included a majority of female participants, thus minimizing the exploration of gender differences. In addition, over 82% of the sample
was African American. It should also be noted that the current sample sought treatment for their weight. Previous studies have found that treatment seeking samples of overweight adolescents manifest greater psychosocial distress than those who do not seek treatment (Braet et al., 1997; Britz et al., 2000; Vlierberghe et al., 2009; Wardle & Cook, 2005). Considering the restricted scope of the study (e.g., gender, race/ethnicity, average BMI above 99th percentile, treatment-seeking), results are limited in their generalizability. However, as mentioned previously, this population is at especially high-risk for poor physical and psychological well-being.

Another limitation is that there was limited variability in scores on many of the constructs assessed (especially body mass and body fat percentage). This restricted variability can make it difficult to identify significant relationships among variables (Crocker & Algina, 1986). Finally, one additional concern regarding the current study is the attrition rate of 67%. Although this percentage is not ideal, differences between the T.E.E.N.S. program and other obesity interventions might account for the discrepancies in retention rates. For example, analyses for the Go Girls program (Resnicow et al., 2000, 2005) included participants who completed any single physiological or dietary measure at post-testing. In the current study, participants had to complete most of their physiological and psychosocial measures at both baseline and post-testing in order to be included in the analyses. Moreover, it is important to note that program activities occurred immediately following school in community or local apartment spaces. This location is thus very different from the T.E.E.N.S. program.
One of the Go Girls’ interventions was conducted in churches in participants’ communities. Reported attrition rates were 73%. However, churches who reported an average family income below $40,000 were excluded from study participation. It is plausible that families with less financial resources (such as those enrolled in T.E.E.N.S.) would face greater barriers to participation in this type of program. In fact, parents participating in the Go Girls focus groups reported transportation as one potential barrier to their adolescents’ participation in activity-oriented events. In the Go Girls high-intensity group (i.e., met weekly for six months, received healthy eating or physical activity reminders via two-way pagers, and monthly motivational interviewing calls), the average participant completed only 57% of the sessions. In the current study, to maintain program eligibility, participants had to comply with at least 70% of T.E.E.N.S. activities. Perhaps attrition would have been lower if attendance requirements were less stringent, but program outcomes may have also suffered.

Additional studies reported higher retention rates than the T.E.E.N.S. program. However, these programs vary from the present intervention in several ways. In many cases, sessions were held at the participants’ school, thus significantly reducing burden on the family (Yin et al., 2005; Resnicow et al., 2000). Other interventions were conducted at inpatient (Braet et al., 2004) or residential camp facilities (Walker et al., 2003). Although participation rates are very high in these examples, residential weight loss programs are often extremely expensive and selective.

The ethnic and socio-economic distribution of the current study also differed from that reported by others. For example, Park et al. (2007) had a high proportion of Korean
participants, and Jelalian and colleagues (2006) had a higher proportion of White individuals of middle SES. These other groups likely face fewer barriers, such as money and time, which likely affected participation in T.E.E.N.S. Moreover, Jelalian and colleagues (2006) excluded adolescents with a BMI $\geq$ 80 percent overweight. This is important to note as results of the current study suggested that program non-completers were significantly heavier than completers. As mentioned previously, youth with higher BMIs are more likely to drop out of treatment (Huang et al., 2007; Jelalian et al., 2006; Resnicow et al., 2005). As a result, intentional exclusion of youth with very high BMIs might explain their high retention rates.

Finally, in another obesity intervention program (Reinehr et al., 2006), nearly 86% of participants completed baseline and one year post-test assessment. However, prior to study enrollment, interested children were asked to “prove their motivation” (p. 490) via questionnaire and minimum participation in community physical activity groups (i.e., at least 8 weeks). Taken together, there are a number of reasons the current study’s retention rates seem smaller than other obesity interventions. At the same time, obese, African American youth are more susceptible to obesity related consequences. Thus, future studies should explore options to enhance program participation while also optimizing cost efficiency, enhancing long-term feasibility, and reducing participant burden.

A final shortcoming of the current study is the sample size. Because of the relatively small sample, the study’s power is restricted and outcomes should be interpreted in light of this limitation. However, considering the small sample size,
significant findings are quite robust and should be considered in the development of future research efforts.

**Additional Recommendations for Future Research**

Future research should focus on replicating the current study, especially in larger samples including individuals of different ethnic/racial backgrounds. The statistical power larger samples provide may help clarify the relationships among physical activity, physical fitness and different domains of mental well-being. If future findings parallel the current study’s outcomes, these conclusions could inform more specific treatment plans for vulnerable populations.

Further, studies should continue to investigate peer support and/or interactions as mediators of psychological well-being and health behaviors (Salvy et al, 2008b). If healthy peer relationships are precursors to reducing sedentary, isolative behaviors and increasing involvement in physical activity, interventions should incorporate social skills training components (Salvy et al., 2008a). Moreover, it has been suggested that teasing or peer victimization are barriers for participation in physical activity (Gray et al., 2008), particularly for overweight youth (see Kelly et al., 2009 for a review). Thus, assessment of teasing should be incorporated in future analyses with overweight populations. Additional indicators of fitness, including strength and flexibility, should also be explored in relation to psychosocial functioning. Finally, past research overwhelmingly supports the impact of self-efficacy as a mediator of physical activity (Lubans et al., 2008; Neumark-Sztainer et al., 2003). Assessment of this construct in future research
could clarify whether obesity interventions should focus more on promoting exercise self-efficacy, in addition to increasing activity levels.

Another variable worthy of considerable attention in future research is self-esteem. A longitudinal study assessing the relationship between BMI and self-esteem in children concluded that obesity precedes low self-esteem in many children, thereby suggesting a causal relationship (Hesketh et al., 2004). A second longitudinal study demonstrated that self-esteem decreased over time in obese children compared to their non-obese peers (Strauss, 2000). Improvements in self-esteem have also been linked to increased physical activity. For example, one longitudinal study (Schmalz, Deane, Birch, & Davison, 2007) concluded that physical activity in pre-adolescence predicts higher self-esteem in adolescence, especially for girls with higher than average BMIs. Similarly, strength training has been associated with improvements in self-esteem in adolescent girls (Holloway, Beuter, & Duda, 1988).

Finally, the quality of life of the current sample is cause for concern. Generally, obesity interventions do not include psychotherapeutic components. The decision not to incorporate therapeutic services is likely dependent on a number of factors, including cost constraints and time limitations. However, given the poor psychosocial functioning of both the current sample and that of other obese, treatment-seeking adolescents, obesity interventions should make more explicit efforts to assess psychological well-being and make community referrals, as appropriate. Also, if it is suitable for youth to participate in an intervention, perhaps treatment plans should be more individually tailored, considering the current study’s findings. For example, although increases in cardiorespiratory fitness
were associated with decreased depressive symptoms, highly depressed individuals were also more likely to drop out of the intervention. In this case, perhaps outcomes could be maximized if initial treatment goals included alleviating depressive symptoms. Then, aerobic activities could be tailored to maintain and further increase improvements in affective functioning. This is important to consider because, if depressed youth prefer isolate activities, as research suggests (Kelly et al., 2009; Salvy et al., 2008a), placing adolescents in a peer-based environment and encouraging them to exercise may actually be counterproductive.

In sum, the current study provides evidence for the feasibility and efficacy of the T.E.E.N.S. program. It also provides several important directions for future studies. When provided with encouragement, expert instruction, and a safe environment, obese youth were capable of engaging in healthy levels of aerobic and resistance training on a weekly basis, which led to enhanced quality of life, as well as improvements in body composition and health. Equally important is the finding that T.E.E.N.S. participants demonstrated no significant impairments in depression or school functioning, supporting the overall safety of the program.
List of References
References


Department of Health and Human Services (HHS) and the Department of Agriculture (USDA). *The Dietary Guidelines for Americans, 2005*, 20.


SPSS 15.0 Command Syntax Reference 2006, SPSS Inc., Chicago Ill.


Appendix A

Models Evaluated

**Intercepts-Only Model**

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Vita

Nichole Rhea Kelly was born October 24, 1981 in Tucson, Arizona. She graduated from Massaponax High School in Fredericksburg, Virginia in June of 2000. She completed her undergraduate studies in May of 2004 at the University of Virginia (UVA), in Charlottesville, Virginia with a Bachelor of Science in Psychology. During her time at UVA, she worked as a research assistant for Dr. Bethany Teachman, examining mental health stigma, anxiety/phobia, and disgust cognitions. After finishing her undergraduate studies, she remained in Charlottesville for one year, working as a research assistant for Dr. Melvin Wilson and the Early Steps Project, a multi-site, randomized control-group trial, evaluating a family-centered intervention for reducing the early emergence of risk in young children, including aggressive and withdrawn behavior and academic readiness. In June of 2005, she moved to Boulder, Colorado where she worked with the Women’s Wilderness Institute, a non-profit organization. A year later, she spent 10 months in Austin, Texas at the Austin Area Urban League (AAUL). Nichole came to Richmond, Virginia in May of 2007 to begin graduate work in the doctoral program in Counseling Psychology at Virginia Commonwealth University under the direction of Dr. Suzanne Mazzeo. She continues to work with Dr. Mazzeo and fellow lab members on obesity- and eating disorder-related program and research design. Specific responsibilities include managing large data sets, publications, grant submissions, and training and coordinating undergraduate research assistants. She has research and clinical interests in eating and anxiety disorders, as well as personality and cognitive assessment.