The Effects of Aerobic Exercise on Psychosocial Functioning of Adolescents Who Are Overweight or Obese

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Objectives To evaluate effects of stationary cycling to music versus interactive video game cycling on psychosocial functioning in obese adolescents. Methods 30 obese adolescents aged 12–17 years were randomized to twice weekly laboratory-based sessions of stationary cycling to music or interactive video game cycling for a 10-week trial. Participant’s self-reported measures of scholastic competence, social competence, athletic competence, body image, and self-esteem were obtained. Aerobic fitness and body composition were directly measured. Results Although no differences emerged between exercise groups over time, when collapsed across exercise modality, significant pre-post improvements were found for body image, perceived scholastic competence and social competence. Changes in aerobic fitness, but not body composition, were positively associated with psychosocial functioning. Conclusions Aerobic exercise was associated with improvements in body image, perceived academic performance, and social competence in obese adolescents, and these psychological benefits were related to improved aerobic fitness but not changes in body composition.

Key words body image; exercise; pediatric obesity; psychological functioning.

Obesity rates in children and youth have increased dramatically in North America, with approximately one in three youth classified as overweight or obese (Hedley et al., 2004; Shields, 2006). Epidemiological data show that obese youth are less aerobically fit than their normal weight counterparts (Johnson et al., 2000; Mamalakis, Kafos, Manios, Anagnostopoulou, & Apostolaki, 2000), which is concerning given poor aerobic fitness is a strong predictor of metabolic disorders (Eisenmann, 2003) and cardiovascular disease risk factors in youth (Thomas, Baker, & Davies, 2003). Although much attention has been paid to the untoward medical conditions associated with obesity in youth, such as type 2 diabetes, high cholesterol, hypertension, and obstructive sleep apnea (Dietz, 1998; Ebbeling, Pawlak, & Ludwig, 2002), there is a growing body of evidence indicating the deleterious psychosocial sequelae of obesity in youth may be more common than the medical comorbidity (Dietz, 1998). This includes, but is not limited to, depression (Goldfield et al., 2010a; Goodman & Whitaker, 2002), weight-based teasing (Eisenberg, Neumark-Sztainer, & Story, 2003; Goldfield et al., 2010b), diminished self-esteem (Wang, Wild, Kipp, Kuhle, & Veugelers, 2009), and social isolation and discrimination (Latner & Stunkard, 2003).

Another reliable correlate of obesity in adolescence is body image dissatisfaction. Mounting evidence from systematic reviews indicates that overweight/obese youth exhibit greater dissatisfaction than normal-weight peers (Goldfield et al., 2010a; Ricciardelli & McCabe, 2001). This is clinically relevant because body dissatisfaction often leads to strict
dieting practices in attempts to lose weight (Garner, 1997). However, dietary restraint is well documented to be a risk factor in the development and maintenance of binge eating and other eating disorders (Polivy & Herman, 1985), and is cross-sectionally associated with obesity (Claus, Braet, & Decaluwe, 2006) and predictive of future weight gain in youth (Field, Austin, Taylor, & Malspeis, 2003).

The social stigma and discrimination against obese individuals, which is evident in young children (Lattner & Stunkard, 2003), often leads to social isolation and alienation in this population, which frequently results in diminished peer support and social problems (Gunnarsdottir, Njardvik, Olafstoddir, Craighead, & Bjarnson, 2012). Moreover, obesity in youth has recently been associated with increased prevalence of learning problems, Attention Deficit Hyperactivity Disorder (ADHD), school suspensions, as well as school absenteeism, all of which reduces academic performance (Daniels, 2008; Davis, Levitan, Smith, Tweed, & Curtis, 2006; Waring & Lapane, 2008). Taken together, interventions that can increase obese adolescents’ body image, self-esteem, social functioning, and academic performance, would likely result in improved emotional well-being.

Based on evidence from systematic reviews, aerobic exercise and other forms of physical activity are common front-line prescriptions for psychological problems such as depression and anxiety in youth (Ekeland, Heian, & Hagen, 2005; Larun, Nordheim, Ekeland, Hagen, & Heian, 2006). However, other psychological effects of exercise in youth are not well studied. Regarding obese adolescents, it has been shown that aerobic exercise improved physical self-perceptions and global self-esteem (Daley, Copeland, Wright, Roalle, & Wales, 2006), findings consistent with those from a physical activity intervention in obese pre-adolescents (Goldfield et al., 2006b).

Relatively few studies have examined exercise interventions on body image in adolescents. A recent meta-analytic review of 57 studies showed exercise improved body image, but only two intervention studies were conducted in adolescents, and neither used obese samples who are at higher risk of body image dissatisfaction (Campbell & Hausenblas, 2009).

There is emerging research from both narrative and systematic reviews that school-based physical activity interventions may enhance academic performance and fluid intelligence (Rasberry et al., 2011; Shephard, 1997). Relatedly, a recent study of over 7,000 adolescents aged 15–16 years found high levels of physical activity was associated with higher academic performance and plans for higher education (Kantomaa, Tammelin, Demakakos, Ebeling, & Taanila, 2010). Physical activity can be differentiated from aerobic exercise in that it is typically measured by the accumulation of activity level throughout the day across varying intensities, whereas aerobic exercise typically consists of a planned or structured bout of aerobic activity for a specified duration and intensity. Although very few studies have examined the effects of aerobic exercise on academic performance, one laboratory based study found that single bouts of walking on a treadmill at moderate intensity for 20 minutes produced acute increases in standardized academic achievement scores in pre-adolescent youth (Hillman et al., 2009). To our knowledge, there have been no studies examining the effects of regular aerobic exercise on academic functioning in adolescents, especially those who are obese.

In order to glean optimal psychological and physical health benefits of aerobic exercise prescriptions, it is critical that participants exhibit strong adherence and low attrition. However, this is very difficult for obese adolescents given they report that aerobic exercise is more uncomfortable and unpleasant than their normal weight peers (Ekkekakis & Lind, 2005), and this high level of exercise intolerance is believed to play a critical role in the high attrition rates observed in meta-analytic reviews of exercise interventions in obese youth (Epstein & Goldfield, 1999). Therefore, it is critical that new and innovative intervention strategies of enhancing exercise adherence and minimizing attrition be developed and tested in this high-risk population.

One such innovation is the Gamebike®, which offers the user the opportunity to play interactive video games (Sony Play Station 2 console) while cycling on a stationary bike. The interactive component is captured by the feature that enables one’s character in a video game, often a race-based game (i.e., mountain biking down a hill), to move faster by increasing the cycling cadence, and vice versa. Cessation of pedaling on the Gamebike® results in one’s character remaining stationary. Given that adolescents are fond of technology and video games in particular (Jenkin, 2000), the Gamebike® may represent a novel and enjoyable method of increasing adherence and therefore energy expenditure necessary to accrue psychological and physiological health benefits. Warburton et al. (2007) found that the Gamebike® produced greater physiological health benefits compared with controls riding on a stationary bike with no distraction in adults, and these effects were mediated by the higher attendance rate observed in the Gamebike® relative to controls (78% vs. 48%). Although no intervention studies have examined the psychological impact of the Gamebike®, one study found that a single 30-minute bout of exercise using interactive video game technology produced improvements in mood and attention (Russell & Newton, 2008). Although this finding
is encouraging, the psychological impact of this technology remains uninvestigated in youth in the context of an intervention study.

A common form of distraction from discomfort during exercise utilized by many teens is listening to music. A well controlled laboratory study found that simply listening to music can induce psychological benefits such as enhanced happiness and reduced sadness (Hunter, Schellenberg, & Schimmack, 2010). More recently, listening to music while exercising for 20 minutes at 70% of maximal heart rate was also found to promote increase relaxation and reduce stress in university students (Plante, Gustafson, Brecht, Imberi, & Sanchez, 2011). However, the actual psychological effects of listening to music while doing aerobic exercise over the course of an intervention remains uninvestigated in youth, especially obese youth who may potentially benefit the most from this form of distraction.

Given the paucity of data on the psychological effects of aerobic exercise in adolescents who are obese, combined with the lack of data on promising innovative interventions designed to promote adherence and therefore psychosocial benefit in this high-risk population, the current study is designed to fill this gap. More specifically, the purpose of this trial is to comparatively examine the effects of stationary cycling to music versus stationary cycling while playing interactive video games (i.e Gamebike®) on body image, perceived scholastic ability, social acceptance, athletic competence, and global self-esteem. Given research has shown that the Gamebike increases energy expenditure by increasing adherence (Warburton et al. 2007), combined with some evidence that the Gamebike® can provide psychological benefit, at least in the short-term, we hypothesized that obese adolescents randomized to the Gamebike® (interactive video game cycling) condition would show greater improvements in psychosocial functioning compared to those randomized to stationary cycling while listening to music. A secondary aim of this study was to compare the association between changes in psychosocial functioning with changes in fitness and body composition. We previously compared the Gamebike® versus Music on physiological outcomes, but to the best of our knowledge, this is the first test of the effects of the Gamebike® on psychosocial factors in obese youth.

Methods

Participants

As illustrated in Figure 1, a total of 150 families were screened through the Endocrinology clinic at a local children’s hospital to determine eligibility. Thirty families met the following inclusion criteria: consenting and assenting youth between the ages of 12–17 with a BMI above the 95th percentile for age and gender based on Centers for Disease Control and Prevention’s growth chart data (http://www.cdc.gov/growthcharts) or a BMI > 85th percentile for age and gender with any of the following: elevated fasting glucose or 2-hour Oral Glucose Tolerance Test (OGTT) indicative of impaired glucose tolerance, elevated fasting triglycerides, insulin, high-density lipoprotein-cholesterol (HDL-C), low-density lipoprotein-cholesterol (LDL-C), or total cholesterol/HDL-C > 90th percentile (Daniels & Greer, 2008), blood pressure above the 90th percentile (U.S. Department of Health and Human Services, 1991) or first degree relative with type 2 diabetes or cardiovascular disease. Potential participants meeting these criteria, who did not have a medical condition that altered intestinal absorption or otherwise influence response to activity intervention or make vigorous exercise dangerous, or other illness assessed by their physician making participation inadvisable, were considered eligible to participate. Participants were excluded if they were diagnosed with type 2 diabetes by the study team’s endocrinologist, taking any medication and/or supplement that could affect body composition, lipids, or glucose metabolism; had significant weight changes (increase of ≥ 10%, or decrease ≥ 5% of body weight as assessed by self-report during the two months before enrolment); had participated during the previous 4 months in physical activity programs ≥2 times per week for at least 20 minutes per session or were planning to start one outside of this study; presented with an eating disorder; were severely depressed or who were currently abusing alcohol or drugs, evaluated by standardized questionnaires and clinical interview. The research coordinator completed the interview that we developed to evaluate inclusion/exclusion criteria. The interview was conducted under the supervision of an endocrinologist and clinical psychologist (lead author of this manuscript and PI of the study). The research coordinator had a diverse background with a Master degree in Exercise Physiology and Nutritional Sciences, as well as expertise in Psychology and behavior change processes in both community and clinical settings, as well as in a research context. The Beck Depression Inventory (BDI; Beck, Steer, & Brown, 1996) was used to assess severity of depression and anyone scoring 30 or higher, indicative of “severe depression,” would have been excluded from this study but no cases were excluded on this criterion. We administered the Eating Disorder Diagnostic Survey (EDDS; Stice, Fisher, & Martinez, 2004) to assess for the presence of an eating disorder but no subjects were excluded based on this criterion either.
All youth and/or guardians signed consent and assent forms according to standard procedures. Participants were first recruited in May 2007, and the final assessment was completed in March 2009. The protocol was reviewed and approved by the host institution’s Research Ethics Board.

**Experimental Design**

Fifteen youth were randomly assigned to the interactive video game cycling condition, and 15 youth were randomized to the stationary bike music group. The randomization sequence was stratified by sex as it is well known that boys are more active than girls (Sallis, Prochaska, & Taylor, 2000), and participants were randomized to groups using a computer-generated sequence of random numbers in small blocks of four subjects. Four of the 30 participants that had met all inclusion criteria and consented to participate dropped out of the study, primarily due to lack of interest and perceived lack of time. However, dropouts did not differ significantly from completers in terms of body composition, lipid profile, and psychosocial profile at baseline and all dropped out early on in the program. This resulted in a final sample size of 13 subjects (7 males, 6 females) in each group. As a behavioral intervention, it was not possible for participants to be blinded. Participants and their families were reimbursed $10 per visit to the laboratory for parking costs, and each participant was given a $20 gift certificate to a movie theatre following completion of the trial.

**Protocol for Interactive Video Game Cycling**

Participants in this group were required to exercise on a GameBike® (Cat Eye Electronics Ltd, Boulder, CO, USA) interactive video gaming system that was interfaced with a Sony Play Station 2® (Sony computer Entertainment America Inc., Foster City, CA, USA) and a 42” flat screen television monitor. The GameBike® has a handlebar mounted game controller allowing the participant to play most Sony Playstaton 2 race-based video games. Participants were allowed to select, from a variety of choices, video games to play while cycling and were permitted to switch games during the exercise sessions if they so desired. The participant’s cycling cadence on the

<table>
<thead>
<tr>
<th>Families Assessed for eligibility (n= 150)</th>
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<tbody>
<tr>
<td>Excluded (n= 120)</td>
</tr>
<tr>
<td>-Not meeting inclusion criteria (n= 41)</td>
</tr>
<tr>
<td>-unwilling to participate (n=79)</td>
</tr>
<tr>
<td>30 Randomized</td>
</tr>
<tr>
<td>Allocated to video game cycling (n= 15)</td>
</tr>
<tr>
<td>Received allocated intervention (n= 15)</td>
</tr>
<tr>
<td>Lost to follow-up (n= 2)</td>
</tr>
<tr>
<td>Analyzed (n=13)</td>
</tr>
<tr>
<td>Allocated to music cycling (n= 15)</td>
</tr>
<tr>
<td>Received allocated control (n=15)</td>
</tr>
<tr>
<td>Lost to follow-up (n= 2)</td>
</tr>
<tr>
<td>Analyzed (n=13)</td>
</tr>
</tbody>
</table>

*Figure 1. Study enrollment.*
GameBike® dictated how fast they moved in the virtual world on screen. Participants were shown how to adjust the resistance on the bike and were told that they could exercise at any intensity and duration they desired. Participants were asked to come to the lab for two, 60-minute sessions per week for 10 weeks. Although participants were required to stay in the lab for 60 minutes, they could take breaks or stop cycling when they wanted. During each session, subjects’ heart rate was monitored and recorded using a Polar™ heart rate monitor (polar S-510, Polar Electro Y, Kempele, Finland).

**Protocol for Stationary Cycling to Music**

Participants randomly assigned to stationary cycling to music exercised twice weekly for 10 weeks on the GameBike® with the game console turned off. The instructions given to this group were the same as for that described above for the video game condition. The GameBike® was used by both groups to ensure a level of consistency between interventions. Participants were allowed to listen to music of their choice via radio, CD, or a personal music device. Most youth exercise to music; therefore, we incorporated music into the design to provide a more stringent comparison to the Gamebike® while improving the ecological validity of the research design. We also wanted to maximize compliance and believed that expecting overweight/obese adolescents, who often report disliking aerobic exercise, to bike in a lab with no form of distraction would result in high drop-out rates, evidenced by the Gamebike® study in adults by Warburton et al. (2007).

**Common Components**

No recommendations were provided concerning exercise training regime on intensity or duration in either condition. Two supervisors trained in exercise physiology ran the sessions, which were booked anytime after school hours between 4 pm and 7 pm in the evening during weekdays, the timing of which was dictated by participants in the interest of accommodation. All participants biked alone (not with other participants) but were supervised by the two exercise specialists.

**Measurement**

**Anthropometry and Body Composition**

Height was measured using a wall-mounted stadiometer (Seca GmBH & Co Kg, Hamburg, Germany). Body weight, body mass index (BMI = kg/m²), and body composition were assessed using a Tanita (model 300-A) bioelectrical impedance scale (Tanita Corporation of America, Inc., Arlington Heights, IL, USA). Height, weight, and percent body fat were measured in duplicate, and the mean was used to resolve any discrepancies in measurement. Overweight status was defined as having a BMI between the 85–94th percentile for age and sex, while obesity was defined as a BMI ≥ 95th percentile for age and sex based on Center for Disease Control growth charts (www.cdc.gov/growthcharts). Previous work has found measures from the Tanita BIA in overweight/obese children and the gold standard dual energy X-ray absorptiometry (DEXA) to have correlations for percent body fat, fat mass, fat free mass of 0.85, 0.97, and 0.94, respectively (Goldfield et al., 2006a).

**Aerobic Fitness**

Submaximal fitness was assessed using a graded cycle ergometer protocol with the Gamebike®. Subjects were asked to begin cycling, at a constant speed, on the Gamebike’s® Level 1 resistance for 3 min. Following this, and while maintaining the same speed, the workload increased by ~10 watts every 2 min by increasing the bike’s resistance up one level at each 2-min interval until the subject reached volitional fatigue. Aerobic fitness was assessed by peak heart rate (HR), and rate of perceived exertion (RPE) was measured and recorded at the end of each 2-min interval using the Borg scale, which ranges in scores from 6 (very low exertion) to 20 (very high exertion—exhausted). The Borg scale has been validated in adults (Stamford, 1976) and adolescents (Gros lambert & Mahon, 2006). The submaximal fitness test was completed by each subject at baseline and post intervention.

**Body Image**

The Body Esteem Scale for Adolescents and Adults (BESSA) is a 23-item scale that contains positive and negative assertions about the body and the persons’ appearance. It is adapted to ages 12–25 years and is rated on a 5-point likert scale, from 0 (never) to 4 (always). Negative items are reversed scored so that a high score always reflects a positive value judgment of the body. Mendelson, Mendelson, and White (2001) factor analyzed the scale which yielded three factors of body esteem (BE) in adolescents and adults: Appearance esteem (10 items, scores range between 0 and 40) deal with general feelings around one’s looks (e.g., I like what I look like in pictures), Weight esteem (8 items, scores range between 0 and 32) concerns the extent to which the person is happy about his or her weight and how much he or she would like to change it (e.g., I am satisfied with my weight), and External attribution (5 statements, scores range from 0 to 20) concerns how others perceive their looks (e.g., my looks makes boys/girls attracted to me). Cronbach’s
Psychosocial Functioning
Self-perceptions on psychosocial factors were assessed by Harter’s 35-item Self-Perceptions Profile for Adolescents (SPPA; Harter, 1988). This inventory is designed to measure adolescents’ perceived competence in six domains of functioning: Scholastic ability (5 items), Social competence (10 items), Athletic competence (5 items), Physical appearance (5 items), Behavioral conduct (6 items), and Global self-esteem (4 items). These subscales are empirically derived and validated by factor analysis (Eklund, Whitehead, & Welk, 1997; Harter, 1988). Items are rated on a 4-point likert scale, from 1 (describes me very poorly) to 4 (describes me very well). Negative items are reversed scored so that a higher score always reflects more positive self-perception on domains of psychosocial functioning. The SPPA has been demonstrated to be an appropriate measure for adolescents between the ages of 13 to 20. The SPPA has been found to have adequate levels of internal consistency with alpha values ranging from 0.69 (Scholastic ability) to 0.87 (Physical appearance) (Wichstrom, 1995). The SPPA has also been found to have good levels of convergent validity (Wichstrom, 1995). It is important to note that the Behavioral Conduct scale was removed from the analyses because it is not pertinent to the aims of the study, and the Physical Appearance subscale was dropped because this construct is measured comprehensively by the BESSA.

Data Analytic Plan
The distributions of all dependent variables were examined and no transformations were required based on the criteria established by Tabachnick & Fidell (2007). Independent t-tests were conducted to determine if any differences between groups existed on variables of interest at baseline. The between and within-group effects of exercise modality on changes in psychosocial functioning were assessed using a mixed analyses of variance (ANOVA) models, whereby the between subjects factor was Group (stationary cycling to music vs. cycling while playing video games) and the within (repeated) measures factor was Time (baseline vs. post-intervention). ANOVAs were conducted on four domains of psychosocial functioning assessed by the SPPA, as well as three body image subscales from the BESSA serving as primary dependent variables. Pre-post change scores were created, and the magnitude of correlation between changes in psychosocial functioning, aerobic fitness, and body composition was evaluated by Pearson Product Moment correlations. Chi-square analyses were used to compare groups on the percentage of sessions attended. Effect sizes associated with pre-post change scores associated with the ANOVAs were calculated by the following equation: ES = mean difference between baseline and post-intervention divided by the standard deviation of the change scores, as suggested by Cohen to account for repeated measures analysis (Cohen, 1988). In all analyses, we used a two-tailed alpha values set at 0.05.

Table I. Baseline Characteristics of the Sample Presented as Means and Standard Deviationsa

<table>
<thead>
<tr>
<th>Variable</th>
<th>Music (n = 13)</th>
<th>Video Game (n = 13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>15.1 ± 1.8</td>
<td>13.9 ± 1.4</td>
</tr>
<tr>
<td>Gender (F/M)</td>
<td>7/6</td>
<td>7/6</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>165.6 ± 8.0</td>
<td>163.8 ± 4.1</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>105.3 ± 23.8</td>
<td>93.1 ± 20.8</td>
</tr>
<tr>
<td>Body mass index (BMI = kg/m²)</td>
<td>39.3 ± 9</td>
<td>35.5 ± 9.3</td>
</tr>
<tr>
<td>BMI percentile</td>
<td>97.8 ± 2.7</td>
<td>97.9 ± 1.5</td>
</tr>
<tr>
<td>Fat mass (kg)</td>
<td>47.3 ± 20.8</td>
<td>43.7 ± 21.5</td>
</tr>
<tr>
<td>Fat free mass (kg)</td>
<td>57.0 ± 13.3</td>
<td>50.9 ± 8.9</td>
</tr>
<tr>
<td>Body fat percentage</td>
<td>43.7 ± 11.8</td>
<td>45.1 ± 9.7</td>
</tr>
<tr>
<td>Fitness (peak heart rate—beats per minute)</td>
<td>172.1 ± 16.0</td>
<td>177.0 ± 21.5</td>
</tr>
<tr>
<td>Final ratings of perceived exertion</td>
<td>17.8 ± 2.2</td>
<td>15.8 ± 5.0</td>
</tr>
<tr>
<td>Scholastic competence</td>
<td>14.7 ± 3.8</td>
<td>14.1 ± 2.4</td>
</tr>
<tr>
<td>Social acceptance</td>
<td>32.0 ± 4.8</td>
<td>32.3 ± 5.0</td>
</tr>
<tr>
<td>Athletic competence</td>
<td>11.2 ± 3.5</td>
<td>12.1 ± 4.4</td>
</tr>
<tr>
<td>Global self-esteem</td>
<td>11.9 ± 3.4</td>
<td>11.5 ± 2.5</td>
</tr>
<tr>
<td>Appearance esteem</td>
<td>12.3 ± 3.9</td>
<td>12.0 ± 3.8</td>
</tr>
<tr>
<td>Weight esteem</td>
<td>8.9 ± 5.3</td>
<td>9.7 ± 4.1</td>
</tr>
<tr>
<td>External attribution</td>
<td>6.7 ± 2.4</td>
<td>8.3 ± 4.6</td>
</tr>
</tbody>
</table>

aNo significant differences between exercise groups at baseline.
video game cycling group, and 85% (11 of 13) of participants in the music group falling in the obese range (e.g., BMI ≥ 95th percentile for age and sex, a group difference that was not significant). Both groups exhibited a high rate of attendance, although the percentage of sessions attended was higher for the music group compared with the video game group (19 of 20 sessions—95% vs. 17 of 20 sessions—85%, p < 0.005). The Gamebike condition averaged 54.3 ± 16.9 min vs. 56.3 ± 4.1 min of exercise per session for the music group, a difference that was not statistically significant.

ANOVA indicated that none of the Group × Time interactions were significant for any of the psychosocial variables. However, as shown in Table II, there were many significant main effects of Time indicating changes in baseline versus post-intervention values, including perceived Scholastic competence [F(1, 24) = 4.5, p = 0.043, ES = 0.43] and Social acceptance [F(1, 24) = 6.7, p = 0.016, ES = 0.53]. Significant main effect of Time was also found on Appearance esteem [F(1, 24) = 10.4, p = 0.004, ES = 0.66] and Weight esteem [F(1, 24) = 12.3, p = 0.002, ES = 0.69]. Changes from baseline to intervention were not significant for Athletic competence, Global self-esteem, or External attribution (Table II).

ANOVAs indicated no Group × Time interactions on the anthropometric or fitness outcomes. However, there were main effects of Time whereby significant pre-post intervention improvements were found for aerobic fitness (peak HR at a given work load: 174.5 ± 18.7 vs. 166.1 ± 21.1, p < 0.05) and percent body fat (44.5 ± 10.7 vs. 42.8 ± 19.5, p < 0.05). There were no significant Group × Time interactions or main effects for other body composition variables.

As shown in Table III, correlational analyses of baseline to post-intervention change scores indicated that increases in aerobic fitness were associated with improvements in self-perceived Scholastic competence (r = 0.47, p = 0.016), Social competence (r = 0.38, p = 0.05), Appearance esteem (r = 0.76, p = 0.001), and Weight esteem (r = 0.48, p = 0.013). Correlations between changes in psychosocial functioning and changes in body composition revealed that changes in body fat percentage were significantly inversely associated with changes in perceived Social acceptance (r = −0.43, p = 0.032). However, no other changes in body composition were significantly associated with changes in psychosocial factors (Table III).

### Discussion

We hypothesized that stationary cycling while playing video games would produce greater psychosocial benefit than stationary cycling to music of participants’ choice. This hypothesis was not supported in that there were no differences in changes in psychosocial functioning between exercise modalities. However, when collapsed across groups, the twice weekly supervised aerobic exercise sessions approximating one hour per session at moderate intensity was associated with improvements in perceived scholastic competence, social competence, and several markers of body image such as appearance esteem and weight esteem. In addition, improvements in aerobic fitness were found to be more closely associated with these psychosocial benefits of exercise compared with changes in body composition. These findings have important clinical implications for a sample of obese adolescents at high risk for psychopathology.

We found that our supervised aerobic exercise intervention was associated with improved perception of social

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### Table II. Effects of Aerobic Exercise on Changes in Psychosocial Functioning

<table>
<thead>
<tr>
<th>Variables</th>
<th>Baseline (n = 26)</th>
<th>Post-intervention (n = 26)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td></td>
</tr>
<tr>
<td>SPPA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scholastic competence</td>
<td>14.4 ± 3.1</td>
<td>16.8 ± 4.6</td>
<td>0.043</td>
</tr>
<tr>
<td>Social competence</td>
<td>32.3 ± 4.8</td>
<td>34.3 ± 5.4</td>
<td>0.016</td>
</tr>
<tr>
<td>Athletic competence</td>
<td>11.7 ± 3.9</td>
<td>11.7 ± 4.5</td>
<td>0.999</td>
</tr>
<tr>
<td>Global self-esteem</td>
<td>11.6 ± 2.9</td>
<td>11.9 ± 2.5</td>
<td>0.586</td>
</tr>
<tr>
<td>BESSA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appearance esteem</td>
<td>12.2 ± 3.8</td>
<td>17.7 ± 6.2</td>
<td>0.004</td>
</tr>
<tr>
<td>Weight esteem</td>
<td>9.4 ± 4.6</td>
<td>14.3 ± 7.1</td>
<td>0.002</td>
</tr>
<tr>
<td>External attribution</td>
<td>7.3 ± 3.7</td>
<td>7.9 ± 3.1</td>
<td>0.627</td>
</tr>
</tbody>
</table>

Note: SPPA = Self-Perception Profile for Adolescents; BESSA = Body Esteem Scale for Adolescents and Adults.

### Table III. Correlations Between Changes in Fitness, Body Composition, and Psychosocial Functioning

<table>
<thead>
<tr>
<th>ΔSelf-perceptions</th>
<th>ΔFitness</th>
<th>ΔBMI</th>
<th>Δ%BF</th>
<th>ΔFFM</th>
<th>ΔFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scholastic competence</td>
<td>0.47*</td>
<td>−0.31</td>
<td>−0.26</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Social competence</td>
<td>0.38*</td>
<td>−0.33</td>
<td>−0.43*</td>
<td>0.30</td>
<td>−0.35</td>
</tr>
<tr>
<td>Athletic competence</td>
<td>0.20</td>
<td>−0.17</td>
<td>−0.19</td>
<td>0.16</td>
<td>−0.22</td>
</tr>
<tr>
<td>Global self-esteem</td>
<td>0.10</td>
<td>−0.15</td>
<td>−0.01</td>
<td>0.20</td>
<td>−0.27</td>
</tr>
<tr>
<td>Appearance esteem</td>
<td>0.75**</td>
<td>−0.36</td>
<td>−0.11</td>
<td>0.22</td>
<td>−0.16</td>
</tr>
<tr>
<td>Weight esteem</td>
<td>0.48*</td>
<td>−0.35</td>
<td>−0.01</td>
<td>0.27</td>
<td>−0.38</td>
</tr>
<tr>
<td>External attribution</td>
<td>0.15</td>
<td>−0.10</td>
<td>0.10</td>
<td>0.28</td>
<td>−0.16</td>
</tr>
</tbody>
</table>

Note: ΔSelf-perceptions = post-intervention minus baseline changes on self-perception subscales; ΔFitness = baseline minus post-intervention values for peak heart rate (beats per minute), with higher scores indicative of greater fitness; ΔBMI = post-intervention minus baseline changes in BMI; Δ%BF = post-intervention minus baseline changes in percent body fat; ΔFFM = post-intervention minus baseline changes in fat free mass (kg); ΔFM = post-intervention minus baseline changes in fat mass (kg). *p < 0.05, **p < 0.001.
Effects of Aerobic Exercise on Psychosocial Functioning

competence. Although epidemiological studies have shown that physical activity in adolescents is positively associated with social networks (Page et al., 2007) and reduced social inhibition (Kirkcaldy, Shephard, & Siefen, 2002), to the best of our knowledge, we are the first to report this relationship in obese adolescents. Our findings have important clinical relevance given obese youth experience considerable weight-based teasing, discrimination, and bias (Eisenberg et al., 2003; Goldfield et al., 2010b; Latner & Stunkard, 2003) as well as poor social relations with peers (Gunnarsdottir et al., 2012). The social alienation that often occurs with obese youth may prevent them from engaging in many physical or social activities outside the classroom with their peers, and the less opportunities one has to engage socially with peers, the greater the likelihood that social skills will remain poor, thus perpetuating a vicious cycle. Although we are uncertain of the mechanism, it is possible that the highly supportive and empathic style of interactions provided to participants by our research staff and environment in the laboratory resulted in bolstering participants’ perceived social acceptance that generalized beyond the laboratory. A similar mechanism has been described for the way that the psychotherapeutic alliance between therapist and patient is believed to foster psychological growth in psychiatric patients (Lambert & Barley, 2001). The fact that we obtained a 90% compliance to the scheduled exercise sessions in our laboratory, a rate of adherence far higher than most exercise trials in obese youth (Epstein & Goldfield, 1999), is consistent with this hypothesis that they enjoyed attending our sessions. Alternatively, improved social competence was highly correlated with improvements in aerobic fitness, but not body composition, which may suggest that the exercise itself or the consequences of greater fitness may have played a contributing role to improved social competence independent of self-esteem. Future research is needed to replicate these novel findings.

We found that aerobic exercise was associated with perceived improvements in scholastic performance in obese adolescents. Although we are not aware of any other studies examining this in obese youth, our findings are consistent with several other studies with different populations and a recent systematic review that examined physical activity and objectively measured scholastic performance (Rasberry et al., 2011). Although the precise mechanism relating physical activity and improved academic performance may not be well established, there is converging evidence from a meta-analytic review that physical activity enhances cognitive functioning (Sibley & Etnier, 2003). Moreover, studies have shown that improvements in aerobic fitness were positively associated with neuroelectric indices of attention, working memory, response speed, and executive functioning in youth (Hillman et al., 2009; Hillman, Castelli, & Buck, 2005).

Interestingly, we did not find that aerobic exercise improved self-esteem, which is a finding that is inconsistent with many studies in children and youth (Ekeland et al., 2005; Ekeland, Heian, Hagen, Abbott, & Nordheim, 2004). One reason for this discrepancy may be that very few of the exercise interventions conducted in these reviews were in obese adolescents, and it is possible that obese youth may need a longer or more intense intervention than the current one to show improvements in self-esteem. However, we did find that aerobic exercise was associated with marked improvements in body image across several scales, such as appearance esteem, weight esteem, and overall physical appearance. These findings are consistent with a recent meta-analytic review of exercise interventions on body image across the lifespan (Campbell & Hausenblas, 2009), although this review only included two studies in adolescents, neither of which were with overweight or obese adolescents who are at much higher risk of body image dissatisfaction than normal-weight peers (Goldfield et al., 2010a). It is important to note that the improvements in body image from exercise in our trial were realized in the absence of weight loss and only minimal reductions in body fat. These findings have important clinical implications given body image dissatisfaction often leads to restrained eating in attempts to lose weight (Garner, 1997), dietary restraint is associated with an increased risk of binge eating (Polivy & Herman, 1985), and both dietary restraint and binge eating have been shown to prospectively lead to weight gain in youth (Field et al., 2003). Moreover, exercise-induced improvements in body image may help buffer against some of the weight-based teasing and discrimination and bias that is often inflicted on obese children and youth, which can have devastating effects on their emotional well-being (Eisenberg et al., 2003; Goldfield et al., 2010b; Latner & Stunkard, 2003).

It is interesting to note that our aerobic exercise intervention was associated with several psychological benefits but not with physical self-perceptions such as athletic competence, despite improvements in fitness. Although time spent in moderate to vigorous physical activity (MVPA) and fitness is associated with improved motor skills and participation in athletics in youth (Lubans, Morgan, Cliff, Barnett, & Okely, 2010), our exercise program consisted of riding a stationary bicycle which likely did not promote a perception of enhanced athletic skills. Very few intervention studies in obese adolescents have examined the effects of aerobic exercise on physical and global self-perceptions.
However, one randomized controlled trial of aerobic exercise consisting of three sessions per week for 30 min per session at moderate intensity enhanced physical self-worth and global self-esteem at 8 weeks in the laboratory and at 14 weeks, with the latter 6 weeks being home based, but did not find that exercise improved mood (Daley et al., 2006). The discrepant results between our study and Daley et al.'s (2006) could be due to differences in questionnaires used between studies, the increased frequency of weekly exercise (3 × /week vs. 2 × /week) utilized in the Daley et al. study or that cognitive behavioral counseling strategies designed to comply with the aerobic exercise prescription were incorporated in Daley et al.'s (2006) study but not ours. Future research is needed to evaluate more thoroughly the effects of aerobic exercise on physical self-perceptions and motor skills in obese adolescents given these physical attributes are important for participating in more organized athletic and sport activities (Lubans et al., 2010).

The present study has several strengths and limitations. Strengths include the randomized clinical trial design, supervised exercise sessions rather than self-report, validated measures of psychosocial functioning, and objectively measured body composition and aerobic fitness by certified exercise physiologists. In addition, the intervention provided was solely based on aerobic exercise without possible confounding of adjunctive behavioral intervention, making inferences regarding the psychological effects of exercise more direct. Limitations of the study include a small, clinical sample that was laboratory-based so it is uncertain whether findings can be generalized to obese individuals in the natural environment. Limitations in generalizability of findings are also a concern given the sampling bias that resulted from the fact that over half of the participants who were eligible for the study were unwilling to participate. This likely occurred because our budget for this trial was cut and we could not offer adequate incentives, which we believe would have increased the participation rate considerably in this trial, and incentives for participation is critical for the conduct of future behavior change interventions of this nature. In addition, we measured perceived academic performance rather than actual academic performance and it is possible that subject perception regarding academics, as well as other self-perceptions, may not match actual competency in the domains assessed. We did not collect data on parental perceptions of their adolescents’ psychosocial functioning, which could have been used to corroborate the participants’ self-perceptions, and this may have been helpful in providing a source of converging validity of self-reported responses, an issue that should be addressed in future research. We also did not employ a control group, thus we cannot determine the incremental psychosocial benefits of exercising with some form of distraction. Moreover, we did not include a follow-up so it is uncertain whether the psychological benefits observed would be maintained over time. Future research using larger samples, a group that exercises without distraction, and multiple follow-ups are needed to address these limitations.

In summary, we found that stationary cycling to music produced comparable improvements in psychosocial functioning as interactive video game cycling. Given the high cost of the Gamebike, cycling to music may represent a more cost-effective approach of implementing an aerobic exercise program in obese adolescents. Importantly, when collapsed across groups, our twice weekly supervised aerobic exercise program via stationary cycling for approximately 1 hour provided many psychological benefits in overweight and obese adolescents, including enhanced body image, perceived academic competence and social competence. In addition, these psychological benefits appear to be associated with improved fitness rather than changes in body composition. Taken together, our findings are consistent with public health guidelines that call for increased physical activity and fitness among children and youth which have been shown to independently enhance physical and psychosocial health without weight loss (Active Healthy Kids Canada, 2011; Tremblay et al., 2011; World Health Organization, 2010). Moreover, focusing intervention on healthy active living behaviors to promote even modest improvements in fitness rather than focusing on weight loss as the primary outcome may be particularly beneficial for clinicians given sustained weight loss over the long term is difficult to achieve for most obese adolescents (Yanovski & Yanovski, 2003) and adults (Perri, 1998).

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Conflicts of interest: None declared.

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