Abstract

Objectives. While it has also been suggested that resistance training may have a beneficial effect on psychological health in young people, evidence supporting this assertion is limited. The primary aim of this study was to explore the effect of free weights and elastic tubing resistance training on physical self-perception in adolescents.

Design. Randomized controlled trial.

Method. Participants (N = 108, mean age = 14.96 ± .68 years) were randomized to free weights (n = 37) or elastic tubing (n = 41) resistance training groups and a control group was recruited (n = 30). Participants in the resistance training groups completed workloads of 2 sets of 10-12 repetitions on 10 exercises for 8 weeks. Height and weight were measured and bio-electrical impedance analysis was used to assess body composition (body fat %). Muscular strength was assessed using 1 repetition maximum tests for bench press and leg press. Students completed the Children's Physical Self-Perception Profile and two scales developed for the current study to assess resistance training self-efficacy and outcome expectancy.

Results. Physical self-perception remained stable among boys over the study period. Girls in the free weights resistance training group significantly increased their perceived body attractiveness ($p < .01$, $d = .76$) over the study period. The relationship between changes in body fat % and body attractiveness in girls was inverse and marginally significant ($r = -.28$, $p < .10$).

Conclusion. Resistance training programs may improve physical self-perception in adolescent girls. However, additional studies with larger sample sizes and more heterogeneous samples are required to confirm this finding.

The Effects of Free Weights and Elastic Tubing Resistance Training on Physical Self-Perception in Adolescents

Resistance training is exercise designed specifically to increase muscular strength and endurance through increased workload demand and may include the use of free weights, machine weights, elastic tubing/stretch bands, hydraulic machines or body weight (e.g. push-ups, chin-ups) (Stratton et al., 2004). Resistance training has long been considered an important activity for adults and the latest physical activity recommendations for youth, adults, and older adults now include guidelines for resistance training (U.S. Department of Health & Human Services, 2008). Historically, resistance training was not recommended for children and adolescents, due to the perceived threat of injury (Faigenbaum, 2000). However, recent studies have shown that supervised resistance training programs do not appear to have any adverse effects in children and adolescents (Malina, 2006) and in fact may improve cardiovascular fitness, body composition, bone mineral density and blood lipid profiles (Benson, Torode, & Fiatarone Singh, 2008b; Faigenbaum, 2000; Malina, 2006).

It has also been suggested that resistance training may have a beneficial effect on psychological health (i.e. self-concept, self-esteem, anxiety, depression) in young people (Faigenbaum, 2000), yet, evidence supporting this assertion is limited (Stratton et al., 2004). The majority of studies exploring the effects of exercise on psychological health have focused on global self-esteem and self-concept (Ekeland, Heian, & Hagen, 2005) and involved exercise to improve cardio-respiratory fitness. Self-concept is generally viewed as one's awareness of personal characteristics, attributes and limitations and how they compare to others, while self-esteem is the evaluative component of self-concept and refers to the value that individuals place

on their characteristics (Gallahue & Ozmun, 2006). Self-concept is considered to be a hierarchical construct consisting of physical, social and academic dimensions (Marsh, 1990; Marsh & Redmayne, 1994). Physical self-esteem is also thought to include multiple dimensions and these include perceived sport competence, body attractiveness, physical condition, muscular strength and general physical self-worth (Fox & Corbin, 1989).

Adolescence is a critical period for the development of self-concept (Harter, 1999) and physical self-perception has been identified as an important contributor to global self-esteem during this time (Santrock, 2005). The development of positive self-perceptions may be an important foundation for a physically active lifestyle (Weiss & Ebbeck, 1996) and previous studies have found physical self-perception to be associated with physical activity in cross-sectional studies (Daley, 2002; Raudsepp & Hannus, 2002) and to predict physical activity in longitudinal studies (Crocker, Sabiston, Kowalski, McDonough, & Kowalski, 2006).

Previous studies examining the effects of exercise programs on physical self-perception in adults have produced conflicting results (e.g. Alfermann & Stoll, 2000; Asçi, 2002; Asçi, Kin, & Kosar, 1998; Caruso & Gill, 1992). Asçi, (2002) and Alfermann and Stoll (2000) found that 10-weeks of step dance and 6-months of general exercise, respectively, resulted in improvements in physical self-perception in adults. However, Asçi and colleagues (1998) reported that 8-weeks of aerobic dance and step aerobics did not improve physical self-perception in female univeristy students. More recently, the impact of exericse on physical self-perception among adolescents has been explored (Burgess, Grogan, & Burwitz, 2006; Lindwall & Lingren, 2005; Schneider, Fridlund Dunton, & Cooper, 2008). Similar to the adult literature, the majority of studies that have explored the effect of

exercise on physical self-perception in adolescents have focused on aerobic activity. Some studies (Burgess et al., 2006; Lindwall & Lingren, 2005), but not all (Schneider et al., 2008), reported exercise to have significant positive effects on physical self-perception in adolescents. Ceiling effects due to initial high levels of physical self-perception has been offered as explanation for the null findings reported in previous studies (Burgess et al., 2006; Fox, 2000). In additon, insufficient exercise intensity and poor study compliance may also explain the failure of studies to elicit a training effect.

While previous studies have examined the impact of resistance training on global self-esteem and self-concept in youth (Faigenbaum et al., 1997; Holloway, Beuter, & Duda, 1988), little is known about the impact of resistance training on physical self-perception in adolescents. Due to the established benefits of resistance training on physiological outcomes, it is plausible to suggest that resistance training has the potential to positively influence psychological health in adolescents, yet little is known about the volume, intensity, time and type of resistance training necessary to achieve results. It is also unclear if different modes of resistance training (e.g. free weights, body weight, hydraulics, elastic tubing) elicit equal effects on physical self-perception in youth.

Recent reviews examining the effects of exercise on self-esteem and body image have recommended that additional studies are needed to improve our understanding of the dose-effect relationship between different types of exercise and self-esteem (Campbelll & Hsusenblas, 2009; Spence, McGannon, & Poon, 2005). Consequently, the primary aim of this study was to determine the effect of free weights and elastic tubing resistance training on physical self-perception in adolescents. The secondary aim of the study was to examine the relationship between

changes in health-related fitness and changes in physical self-perception in adolescents. We hypothesized that adolescents in both resistance training groups would significantly increase their physical self-perceptions over the study period and that changes in self-perceptions would be associated with reductions in body fat and increases in muscular strength. In our original study we compared the effects of free weights and elastic tubing resistance training on body composition and muscular fitness in adolescents using the same training duration and protocols (Lubans, Sheaman, & Callister, 2010). While both groups made significant improvements in comparison to a non-training control group, the effect sizes observed in the free weights group were generally larger than those identified in the elastic tubing group. We hypothesized that changes in physical self-perception would be larger among those in the free weight tubing group. Gender differences in physical self-perception are generally observed among adolescent populations (Daley, 2002; Jones, Polman, & Peters, 2009; Lubans, Morgan, & McCormack, in press) and Fox and Corbin (1990) have recommended that PSPP analyses should be separated by gender. For these reasons, the impact of resistance training on physical self-perception was examined separately for boys and girls.

Physical activity promotion strategies targeting adolescents should include resistance training to improve muscular fitness (Stratton et al., 2004; U.S. Department of Health & Human Services, 2008) and interventions should be guided by a relevant theory of behavior change (Noar, Melissa Chabota, & Zimmerman, 2008). Bandura's Social Cognitive Theory (SCT: Bandura, 1986, 2004) has been used to develop and evaluate numerous physical activity interventions among youth populations (Lubans, Foster, & Biddle, 2008). In SCT, self-efficacy and outcome expectancy have been identified as central mechanisms of behavior change (Bandura, 2004). Resistance

training self-efficacy refers to an individual's confidence to complete resistance training and outcome expectancy refers to their beliefs about the outcomes of resistance training. An additional aim of this study was to determine and compare the impact of free weights and elastic tubing resistance training on resistance training self-efficacy and outcome expectancy.

Methods

Study Population and Design

Approval for the study was obtained from the University of Newcastle Research Ethics Committee and the school principal from one independent secondary school in Newcastle, New South Wales (NSW), Australia. Information leaflets, parental and participant consent forms were sent home with students and those who returned signed consent forms were permitted to participate in the study. Eligible participants were untrained secondary school students in years 9 and 10. Participants were ineligible if they were currently doing resistance training, had extensive experience in resistance training, or if they had a medical condition or physical injury preventing testing or training. The programs were advertised using information leaflets and the study was promoted by physical educator teachers at the study school.

The study involved two recruitment phases and was conducted from July 2008 to June 2009. In phase one of the study, 79 students were recruited and randomized using a computer-based random number-producing algorithm to elastic tubing or free weight resistance training groups. The randomization process was stratified by gender and year group at school to ensure equal numbers in the two treatment arms. Randomization to training conditions occurred after baseline testing and was conducted by a member of the research team who was not involved in the assessments. In the second phase, a control group was recruited (n = 30) from the

study school and assessed over the period April to June 2009. Participants in the control group were offered the resistance training programs following the completion of the study. The average age of participants was 14.96 ± .68 years and the sample included 52 girls and 56 boys. Most participants spoke English as their first language and were born in Australia (98%). Twelve participants (8 boys and 4 girls) from the free weights RT group dropped out of the study and 25 completed baseline and posttest measures (68%). In the elastic tubing RT group, 32 participants completed the study (78%) and eight participants dropped out (5 boys and 3 girls).

Treatment Conditions

The control group was asked to refrain from any resistance training and maintain their normal physical activity and nutrition behaviors for the study period. The free weights and elastic tubing groups participated in progressive resistance training programs delivered during lunch-time twice a week for 8-weeks. Physical education teachers supervised the sessions and the instructor to participant ratio was 1:15. Before commencing each session, participants completed 5 minutes of cardio-respiratory activity (i.e. cycle or other ergometer) and dynamic stretching (i.e. leg swings, body weights squats). In each session, participants completed 2 sets of 8-12 repetitions (10-12 repetitions in weeks 1-4 and 8-10 repetitions in weeks 5-8) for 10 exercises (session duration 40-50 minutes) and the rest between sets was 60-90 seconds. Participants in the free weights resistance training group used standard dumbbells, barbells and benches. The elastic tubing resistance training group used the elastic tubing resistance training device known as the Gymstick™ (www.gymstick.net). The device consists of a graphite shaft that has elastic tubing with foot straps connected to each end of the shaft enabling the trainer to complete a wide range of resistance exercises. Gymsticks™ are available in five different

resistance levels and the load on each device can be increased by rolling the bar and shortening the elastic tubing. Borg's rating of perceived exertion (RPE) was used to determine the training intensity and progression for both resistance training groups (Borg, 1998). The instructors explained to participants that Borg's RPE scale is used for monitoring an individual's exercise tolerance and was developed to allow exercisers to rate their feelings during exercise. The instructors explained that the RPE scale represents a range of feelings from "*No exertion at all*", rated as 6, to "*Maximal exertion"*, rated as 20. Participants were reminded that their maximal lifts from the testing phase could be considered as "*Maximal exertion"* and lifting the bar with no weight, or little weight could be considered "*Very light*". Participants were then encouraged to achieve an RPE of 15-18 for all exercises completed, which should be considered "*Hard*" to "*Very hard*". Borg's scale is readily learned by older children and adolescents (Williams, Eston, & Stretch, 1991) and is a valid instrument for monitoring exertion in this age group (Robertson & Noble, 1997).

In the current study, participants were encouraged to attend all sessions by the supervising teachers. While goal setting and self-monitoring were not explicitly encouraged in the study, participants were required to record all aspects of their sessions, including volume and perceived exertion. Furthermore, as part of this process, participants were encouraged to progressively overload their training intensity to elicit training effects. These behaviors have been identified as important strategies to improve adherence (Shilts, Horowitz, & Townsend, 2004). Participants in the resistance training groups were asked to maintain normal eating and physical activity patterns over the duration of the study.

Study Measures

All assessments were completed by trained research assistants and inter and intra-rater reliability tests were conducted. Measurements were completed at the study school using the same instruments at each time point. Participants completed the questionnaires before physical assessments to prevent the actual process of assessment influencing their responses.

Muscular strength. Maximal muscular strength was assessed using a progressive repetition maximal lift (1RM) protocol, which includes two phases (Benson, Torode, & Fiatarone Singh, 2008a; Faigenbaum et al., 1988). This method has been found to have good test-retest reliability (r >.93) (Faigenbaum et al., 1988). Further detail of the testing procedures can be found elsewhere (Lubans et al., 2010). Upper body strength was assessed using a supine bench press and lower body strength was determined using an incline seated leg press.

Height and weight. Weight was measured in light clothing without shoes using a portable digital scale (Seca 770, Wedderburn) to the nearest 0.1kg and height was measured to the nearest 0.1 cm using a portable stadiometer (PEb7). Body mass index (BMI) was calculated using the standard equation (weight[kg]/height[m]^2) and age-specific cut-off points from the International Obesity Task Force to determine the prevalence of obesity and overweight in the study sample (Cole, Bellizzi, Flegal, & Dietz, 2000).

Body composition. Percentage body fat, fat mass (FM) and fat free mass (FFM) were determined using the Imp™ SFB7 bioelectrical impedance (BIA) analyzer (Moon et al., 2008; Scharfetter, Brunner, Mayer, Brandstätter, & Hinghofer-Szalkay, 2005). The Imp™ SFB7 is a multi-frequency, tetra polar bioimpedance spectroscopy (BIS) device. In a recent study (Nielsen et al., 2007), tetra polar bioimpedance was found to accurately predict whole body fat free mass (dual-energy

X-ray absorptiometry) in youth (r^2 = .95). Participants were asked to refrain from physical activity before testing and to maintain normal hydration patterns.

Children's Physical Self-Perception Profile (C-PSPP). The adolescent version (Whitehead, 1995) of the original Physical Self-Perception Profile (PSPP: Fox & Corbin, 1989; Fox & Corbin, 1990) was used in the current study to provide a measure of self-esteem in the physical domain. The C-PSPP contains five 6-item subscales: *sports competence, physical condition, strength, body attractiveness,* and *overall physical self-worth*. Harter's general self-worth scale, which is often administered with the C-PSPP, was not included in this study. The C-PSPP uses a four-choice structured alternative format to minimise socially desirable responses. Participants must first decide which of the two statements best describes them and then choose whether the statement is 'sort of true' or 'really true' for them. Each item is scored from 1 (*low-self-perception*) to 4 (*high self-perception*). The validity of the C-PSPP has been established (Eklund, Whitehead, & Welk, 1997) and the internal consistency of the subscales in the study sample were as follows: *physical self-worth* (α = .88), *sports competence* (α = .86), *physical condition* (α = .82), *body attractiveness* (α = .86) and *strength* (α = .91).

Resistance training self-efficacy and outcome expectancy. To determine the effect of the resistance training programs on psychological determinants of physical activity, participants were asked to complete two scales assessing their beliefs and self-efficacy regarding resistance training at baseline and posttest. Both scales were developed for the current study and were rated on 5-point Likert scales (1 = *Strongly Disagree* to 5 = *Strongly Agree*). *(i) Resistance training outcome expectancy*- This scale included 5-items with the common stem "*If I participate in regular resistance*

training then…". Example item- "*It will help me increase my muscular strength*". Cronbach alpha for the study sample was $\alpha = .83$. *(ii) Resistance training self-efficacy*- This scale included 4-items. Example item- "*I can complete resistance training exercises without the help of someone else (e.g. friend, trainer)*". Cronbach alpha for the study sample was $\alpha = .75$.

Analysis

Data analysis was undertaken using the Statistical Package for the Social Sciences (SPSS, version 16, SPSS Inc., Chicago, Ill, USA) with differences between treatment groups being considered statistically significant at $p < .05$. Structural equation modelling (SEM) in AMOS (version 16, SPSS Inc., Chicago, Ill, USA) was used to examine the psychometric properties of the resistance training self-efficacy and outcome expectancy scales developed for the current study. Confirmatory factor analysis (CFA) using maximum likelihood estimation was used to examine scale consistency and discriminant validity of the two scales. All data were assessed for normality and satisfied the criteria. Differences between groups at baseline and characteristics of completers versus dropouts were tested using independent samples *t* tests. Repeated measures analysis of variance (ANOVA) was used to identify time and group-by-time interaction effects. Where significant effects were found, paired samples t-tests were calculated to determine changes over time within subgroups. Intervention effect sizes (Cohen's *d*) were calculated by subtracting baseline from posttest values then dividing by the pooled standard deviation of change. Effect sizes were defined as small ($d = .20$), medium ($d = .50$) and large ($d = .80$) (Cohen, 1988). Chi-square (χ^2) was used to compare drop-out rates for free weights and elastic tubing resistance training groups. All data are presented as mean (± SD).

Results

Overview

The average age of participants was 14.96 ± .68 years. The majority of participants spoke English as their first language and was born in Australia (Table 1). Nineteen participants (18% of study sample) were overweight or obese (6 in the control group, 7 in the free weights resistance training group and 5 in the elastic tubing resistance training group). Completers are defined as study participants who attended at least 50% of sessions and attended both baseline and posttest assessments. There were no significant differences between completers and drop-outs for any of the outcome variables. Boys and girls in the free weights RT group attended 79% and 73% of training sessions, respectively. The average RPE for each set completed was 14.57 (±1.99) for boys and 14.04 (±1.73) for girls. The dropout rate was higher among participants in the free weights RT group, compared to the elastic tubing RT group (χ^2 = 6.08, $p < .05$).

Effects of Resistance Training on Body Composition and Muscular Fitness

The effects of resistance training on physiological outcomes has been reported elsewhere in detail (Lubans et al., 2010). In comparison to the control group, boys in both RT groups reduced their fat mass and increased their fat free mass resulting in a significant group-by-time interaction effect for body fat % ($p < .01$). Girls in both RT groups improved their body composition over the study period and significant group-by-time interaction effects were found for BMI ($p < .01$) and percentage body fat ($p <$ .01). Girls and boys in both RT groups significantly increased their muscular strength over the study period and the only statistically significant difference between RT groups was found for lower body strength in girls. The increases in strength observed in the elastic tubing RT group [upper body (boys 12%, girls 13%) and lower body (boys

32%, girls, 19%)] increase were smaller than those observed in the free weights group [upper body (boys 24%, girls 23%) and lower body (boys 35%, girls 32%)].

Psychometric Properties of Resistance Training Scales

CFA using ML estimation on the covariance matrix of the nine items of RT self-efficacy and outcome expectancy found that the data were an excellent fit to the hypothesized two-factor model, $\chi^2 = 34.83$ ($df = 34$), $p = .12$ (Figure 1). The factor loadings were significant at $p < .001$ and the standardised loadings ranged from .59 to .78 for the self-efficacy scale and .53 to .83 for the outcome expectancy scale. Inspection of the structure coefficients for both scales indicated a clear distinction between the items comprising the respective factors (Table 2).

Effects of Resistance Training on Psychological Outcomes

The effects of the RT programs on physical self-perception among adolescent boys and girls are reported in Tables 3 and 4, respectively. There were no significant time effects or group-by-time effects for any of the C-PSPP subscales among boys in the study sample. There was a main group effect for body attractiveness ($p < .05$). The effect sizes for both the free weights and the elastic tubing resistance training groups were small ($d \leq .40$). There were no significant group-by-time interaction effects among girls in the study sample. However, there was a significant time effect for body attractiveness. Paired samples t-tests revealed that girls in the free weights resistance training group significantly increased their perceived body attractiveness ($p < .01$, $d = .76$) over the study period.

Small increases in RT self-efficacy and outcome expectancy were observed among boys and girls in the study sample, but there were no significant time effects or group-by-time interaction effects. Effect sizes were generally small to medium for

boys and girls in the three groups. However, a large effect size (d = .77) was found among girls in the free weights RT group who increased their resistance training outcome expectancy over the study period, but the change was not statistically significant (p = .12).

Associations among Variables in the Study Sample

Bivariate correlations among study variables are reported in Table 5 for boys and Table 6 for girls. Changes in body fat % and muscular strength were not associated with changes in physical self-perceptions in boys. Changes in physical self-worth were associated with changes in perceived physical condition (r = .40, p < .05), body attractiveness (r = .38, p < .05) and physical strength (r = .43, p < .01). In girls, the relationship between changes in body fat and body attractiveness was inverse and marginally significant (r = -.28, p < .10); changes in physical self-worth were associated with changes in perceived physical condition (r = .43, p < .01), body attractiveness (r = .46, p < .01) and physical strength (r = .41, p < .01).

Discussion

The primary aim of this study was to explore the effects of free weights and elastic tubing resistance training on physical self-perception in adolescents. Physical self-perception among boys remained stable over the study period and the only significant change among girls was among those in the free weights resistance training group, who increased their perceived body attractiveness. The secondary aim of this study was to explore the relationship between changes in health-related fitness and changes in physical self-perceptions. There was an emerging relationship between reductions in body fat and physical self-worth in boys and between body fat and body attractiveness in girls, but the relationships were not statistically significant.

In the current study, perceived body attractiveness significantly increased among girls in the free weight resistance training group. This is an important study finding, as body image and appearance have emerged as important factors in physical activity decision making among adolescent girls (Biddle & Fuchs, 2009; Biddle, Whitehead, O'Donovan, & Nevill, 2005). Furthermore, evidence suggests that level of body fat is an important predictor of adolescent females' self-concept (Dunton, Schneider Jamner, & Cooper, 2003). This study has shown that 8-weeks of resistance training improves body composition (Lubans et al., 2010), which in turn, improves perceived body attractiveness in adolescent girls. Comparing these findings to the existing evidence base is difficult, as previous studies have focused on children (Duncan, Al-Nakeeb, & Nevill, 2009; Faigenbaum et al., 1997; Sadres, Eliakim, Constantini, Lidor, & Falk, 2001) or adults (Alfermann & Stoll, 2000; Asçi, 2002; Asçi et al., 1998; Caruso & Gill, 1992), included dietary changes in addition to resistance training (Lau, Yu, Lee, & Sung, 2004) or evaluated programs consisting of a range of exercise activities (e.g. aerobics, yoga, kick-boxing, step class) (Burgess et al., 2006; Lindwall & Lingren, 2005; Lubans & Sylva, 2006; Schneider et al., 2008). The effect of aerobic exercise on psychological health cannot be generalised to resistance training which is specifically designed to improve muscular fitness and hypertrophy. Nor can the results from child and adult studies be generalised to adolescent populations, due to the biological, cognitive and socio-emotional changes observed during adolescence (Santrock, 2005). One of the few studies to examine the effects of resistance training on psychological health in adolescents (Lau et al., 2004), found that 6-weeks of resistance training did not decrease depression or anxiety in obese adolescents. However, the study was limited by the small sample size and the authors' failure to report effect sizes.

In the current study, ceiling effects might explain our failure to identify significant changes in physical self-perception among boys in the resistance training groups. The effects of exercise on self-concept are most likely to occur among participants with initially low levels of physical self-perception (Fox, 2000). Participants in both resistance training groups and the control group reported relatively high scores (Mean score $\geq$ 2.50 out of 4.00) on all physical subscales at baseline. Unfortunately, the individuals who would most benefit from resistance training may be reluctant to volunteer for a university study evaluating the effects of resistance training.

Systematic reviews have concluded that exercise has a beneficial effect on global self-esteem in adults (Spence et al., 2005) and youth (Ekeland et al., 2005). Conversely, evidence supporting the positive effect of exercise programs on physical self-esteem in adolescents is less convincing. While some studies have resulted in significant improvements in physical self-perception (Burgess et al., 2006; Lindwall & Lingren, 2005), others have not (Asci, Kin, & LKosar, 1998; Schneider et al., 2008). Lindwall and Lingren (2005) study did not find any significant intervention effects in their intention-to-treat analysis. However, they found significant improvements in body image, perceived sport competence, perceived physical condition and physical self-worth in their completers' analysis. The intention-to-treat analysis is a more conservative analysis (Biddle, Fox, Boutcher, & Faulkner, 2000), as baseline values are carried forward and included in the analyses. It is interesting to note that only 48% of the intervention group were assessed at posttest in the Lindwall and Lingren (2005) study. A completers' analysis was used in the current study for two reasons. First, this was an efficacy trial and we wanted to identify the effects of resistance training on physical self-perception under ideal conditions. Second, there

were no significant differences between completers and dropouts at baseline and approximately 70% of participants completed the study. However, it should be noted no change is different to stability and large variability in physical self-perception has been observed among adults over time (Fortes, Delignieres, & Ninot, 2004).

Researchers examining the effect of exercise on psychological outcomes should consider expectancy effects and demand characteristics. In a study involving healthy young adults, Desharnais and colleagues (Desharnais, Jobin, Cote, Lveesque, & Godin, 1993) found that exercisers who were led to believe that their training was designed specifically to improve self-esteem, showed significant improvements in self-esteem in comparison to a control group who participated in an exercise only program. The authors suggested that exercise may enhance psychological well-being via a strong placebo effect. While we cannot entirely discount a potential placebo effect in the current study, participants in both resistance training groups were compared to a non-training control group and improvements in physical self-perception were only noted in specific sub-domains. Furthermore, the beneficial effect of exercise physical self-perception was not identified to participants as a potential study outcome.

Resistance training self-efficacy and outcome expectancy scales were developed for use in the current study. Both scales demonstrated acceptable internal consistency and future studies should examine the test-retest reliability of these scales. While the changes in self-efficacy and outcome expectancy were not statistically significant, the increases in outcome expectancy observed among girls in the free weights resistance training group were equal to a large effect size. Similar to the current study, Holloway (1988) found that self-efficacy improved in adolescent girls following 12-weeks of resistance training.

The secondary aim of this study was to explore the relationship between changes in health-related fitness and changes in physical self-perception. Although we found an emerging relationship between reductions in body fat and physical self-worth in boys and between body fat and body attractiveness in girls, the relationships were not statistically significant. Interestingly, increases in actual strength were not associated with increases in perceived strength among boys or girls in the study sample. Lindwall and Lindgren (2005) found that changes in physical self-perception were not linked to changes in physiological variables in their 6-month exercise program, despite identifying increases in physical self-perception in the intervention group. Considering the importance of body fat in relation to adolescent females' self-concept (Dunton et al., 2003), it is not surprising to identify a relationship between changes in body fat and perceived body attractiveness among girls in the study.

Sport and exercise psychology researchers often assume that a statistically significant test result represents the true representation of that effect in the study sample (Hagger & Chatzisarantis, 2009). However, statistical significance is highly dependent upon sample size and it is recommended that researchers report effect sizes and discuss their findings in relation to practical or clinical significance (Hagger & Chatzisarantis, 2009; Jacobson & Truax, 1991; Kirk, 1996). In the current study, we identified a number of large effect sizes for free weights resistance training. Assumptions about the genuine significance of large effect sizes can also be erroneous (Hagger & Chatzisarantis, 2009) and Kirk (1996) has recommended that researchers discuss their results in relation to practical significance and explain the extent to which changes may improve health and quality of life. While identifying clinical significance in certain interventions (e.g. weight loss programs) is generally straightforward, explaining the clinical significance or meaning of changes in physical

self-perception is more problematic. Based on the findings from the current study, a 2% reduction in body fat among girls in the free weights group was associated with a large change in perceived body attractiveness. It is difficult to ascertain the implications of such an improvement in perceived body attractiveness. However, we know that body image and appearance are important issues influencing physical activity decision making among adolescent girls (Biddle & Fuchs, 2009) and failure to achieve a culturally determined body shape is associated with low self-esteem in adolescent females (Harter, 1993; Markula, 1995). Longer term studies may help to determine if such changes can contribute to increased physical activity and improved global self-esteem.

Strengths and Limitations

This is the first study to compare the effects of elastic tubing and free weights resistance training on physical self-perception in adolescents. Our study involved an experimental design and where possible we have adhered to the CONSORT statement. Despite these strengths, our study is limited by the following First, the study was underpowered to detect small between group differences. In a recent meta-analysis, Spence, McGannon and Poon (2005) demonstrated that participation in exercise was responsible for only small changes self-esteem. To overcome this limitation, effect sizes have been reported. Future studies need to include a power calculation for key psychological measure as well. Second, our study involved students from one school and therefore, the generalizability of our findings may be limited. Third, while participants were asked to maintain their normal physical activity and dietary patterns over the study period, they were not required to record their behaviors over the study period due to the perceived participant burden. Fourth, although the C-PSPP has been used with Australian youth (e.g. Barnett, Morgan, van

Beurden, & Beard, 2008; Lubans et al., in press), the validity of the scales in this population has not been tested. Finally, our study did not include a long-term follow-up and it is therefore, unknown whether any changes in psychological outcomes persisted when the training stimulus was withdrawn. Longer-term studies are needed to determine if the any psychological benefits from resistance training are maintained.

Conclusions

To the authors' knowledge this is the first study to compare the effects of free weights and elastic tubing resistance training on physical self-perception in adolescents. Our study has shown that 8-weeks of resistance training with free weights improves physical self-perception in adolescent girls. As the impact of resistance training on physical self-perception among adolescent boys was minimal, further research exploring the effects of different training protocols on psychological health is warranted. Future studies with larger sample sizes and more heterogeneous adolescent populations may further improve our understanding of the impact of resistance training on physical self-perception in this population. The study period of only 8 weeks may explain the null findings for many of the physical self-perception domains and studies involving longer-term follow-ups are needed. Strategies to reduce drop-out and increase exercise adherence need to be considered in longer-term studies and programs may benefit from interventions developed in reference to a theory of health behavior, such as SCT (Bandura, 2004). The resistance training self-efficacy and outcome expectancy scales developed for this study may be used in future studies designed to explore adolescents' cognitions related to resistance training. SCT has been successfully applied to the design and evaluation of physical activity interventions among youth. Self-efficacy and outcome expectancy have been identified as

central tenets of Bandura's theory (Bandura, 2004) and important mediators of behavior among youth (Lubans et al., 2008).

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References

Alfermann, D., & Stoll, O. (2000). Effects of physical exercise on self-concept and well-being. *International Journal of Sports Psychology, 30*, 47-65.

Asçi, F. H. (2002). The effects of step dance on physical self-perception of female and male university students. *International Journal of Sports Psychology, 33*, 431-442.

Asçi, F. H., Kin, A., & Kosar, N. (1998). Effect of participation in an 8 week aerobic dance and step aerobics program on physical self-perception and body image satisfaction. *International Journal of Sports Psychology, 29*, 366-375.

Asci, F. H., Kin, A., & LKosar, S. N. (1998). Effects of participation in an 8 week aerobic program on physical self-perception and body images satisfaction. *International Journal of Sport and Exercise Psychology, 29*, 366-375.

Bandura, A. (1986). *Social Foundations of Thought and Action: A Social Cognitive Theory*. Englewood Cliffs, N.J: Prentice-Hall.

Bandura, A. (2004). Health promotion by social cognitive means. *Health Education & Behavior, 31*, 143-164.

Barnett, L. M., Morgan, P. J., van Beurden, E., & Beard, J. R. (2008). Perceived sports competence mediates the relationship between childhood motor skill proficiency and adolescent physical activity and fitness: a longitudinal assessment. *International Journal of Behavioral Nutrition & Physical Activity, 5*, doi:10.1186/1479-5868-1185-1140.

Benson, A. C., Torode, M. E., & Fiatarone Singh, M. A. (2008a). The effect of high-intensity progressive resistance training on adiposity in children: a randomized controlled trial. *International Journal of Obesity*(32), 1016–1027.

Benson, A. C., Torode, M. E., & Fiatarone Singh, M. A. (2008b). Effects of resistance training on metabolic fitness in children and adolescents: a systematic review. *Obesity Reviews, 9*, 43-66.

Biddle, S. J. H., Fox, K. R., Boutcher, S. H., & Faulkner, G. E. (2000). The way forward for physical activity and the promotion of psychological well-being. In S. J. H. Biddle, K. R. Fox & S. H. Boutcher (Eds.), *Physical activity and psychological well-being* (pp. 154-168). New York: Taylor & Francis Company.

Biddle, S. J. H., & Fuchs, R. (2009). Exercise psychology: A view from Europe. *Psychology of Sport & Exercise, 10*, 410-419.

Biddle, S. J. H., Whitehead, S. H., O'Donovan, T. M., & Nevill, M. E. (2005). Correlates of participation in physical activity for adolescent girls: A systematic review of recent literature. *Journal of Physical Activity & Health, 2*, 423-434.

Borg, G. (1998). *Borg's Perceived Exertion and Pain Scales*. Champaign, Ill: Human Kinetics.

Burgess, G., Grogan, S., & Burwitz, L. (2006). Effects of a 6-week aerobic dance intervention on body image and physical self-perceptions in adolescent girls. *Body Image, 3*(1), 57-66.

Campbelll, A., & Hsusenblas, H. A. (2009). Effects of exercise on body image: A meta-analysis. *Journal of Health Psychology, 14*(6), 780-793.

Caruso, C. M., & Gill, D. L. (1992). Strengthening physical self-perceptions through exercise. *Journal of Sports Medicine & Physical Fitness, 32*, 416-427.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). Hillsdale (NJ): Lawrence Earlbaum Associates.

Cole, T. J., Bellizzi, M. C., Flegal, K. M., & Dietz, W. H. (2000). Establishing a standard definition for child overweight and obesity worldwide: international survey. *British Medical Journal, 320*(7244), 1240-.

Crocker, P., Sabiston, C., Kowalski, K., McDonough, M., & Kowalski, N. (2006). Longitudinal assessment of the relationship between physical self-concept and health-related behaviour and emotion in adolescent girls. *Journal of Applied Sport Psychology, 185-200*.

Daley, A. J. (2002). Extra-curricular physical activities and physical self-perceptions in British 14-15-year-old male and female adolescents. *European Physical Education Review, 8*(1), 37-49.

Desharnais, R., Jobin, J., Cote, C., Lveesque, L., & Godin, G. (1993). Aerobic exercise and the placebo effect: A controlled study. *Psychosomatic Medicine, 55*, 149-154.

Duncan, M. J., Al-Nakeeb, Y., & Nevill, A. M. (2009). Effects of a 6-week circuit training intervention on body esteem and body mass index in British primary school children. *Body Image, 6*(3), 216-220.

Dunton, G. F., Schneider Jamner, M., & Cooper, D. M. (2003). Physical self-concept in adolescent females: Behavioral and physiological correlates. *Research Quarterly for Exercise & Sport, 7*(3), 360-365.

Ekeland, E., Heian, F., & Hagen, K. B. (2005). Can exercise improve self esteem in children and young people? A systematic review of randomised controlled trials. *British Journal of Sports Medicine, 39*(11), 792-798.

Eklund, R. C., Whitehead, J. R., & Welk, G. J. (1997). Validity of the Children and Youth Physical Self-Perception Profile: A confirmatory factor analysis. *Research Quarterly for Exercise & Sport, 68*, 240-256.

Faigenbaum, A., Zaichkowsky, L. D., Westcott, W. L., Long, C. J., La Rosa-Loud, R., Micheli, L. J., et al. (1997). Psychological effects of strength training on children. *Journal of Sport Behavior, 20*(2), 164-175.

Faigenbaum, A. D. (2000). Strength training for children and adolescents. *Clinical Sports Medicine, 19*(4), 593-619.

Faigenbaum, A. D., Westcott, W. L., Milliken, L. A., Long, C., La Rosa Loud, R., Delmonico, M., et al. (1988). Relationship between repetitions and selected percentages of the one repetition maximum in healthy children. *Pediatric Physical Therapy, 10*, 110-113.

Fortes, M., Delignieres, D., & Ninot, G. (2004). The dynamics of self-esteem and physical self: Between preservation and adaptation. *Quality & Quantity 38*, 735-751.

Fox, K. R. (2000). Self-esteem, self-perceptions, and exercise. *Journal of Sport & Exercise Psychology, 31*, 228-240.

Fox, K. R., & Corbin, C. B. (1989). The Physical Self-Perception Profile: development and preliminary validation. *Journal of Sport & Exercise Psychology, 11*, 408-430.

Fox, K. R., & Corbin, C. B. (1990). The Physical Self-Perception Profile Manual. In K. R. Fox (Ed.), *PRN Monograph* (pp. 1-19). Northern Illinois: DeKalb, IL: University Office for Health Promotion.

Gallahue, D. L., & Ozmun, J. C. (2006). *Understanding motor development: Infants, children, adolescents, adults* (6th ed.). Boston: McGraw-Hill.

Hagger, M. S., & Chatzisarantis, N. L. D. (2009). Assumptions in research in sport and exercise psychology. *Psychology of Sport & Exercise, 10*, 511-519.

Harter, S. (1993). Causes and consequences of low self-esteem in children and adolescents. In N. Baumeister (Ed.), *Self-esteem: The puzzle of low self-regard* (pp. 87-116). New York: Plenum Press.

Harter, S. (1999). *The construction of self: A developmental perspective*. New York ,NY: Guilford.

Holloway, J., Beuter, A., & Duda, J. (1988). Self-efficacy and training for strength in adolescent girls. *Journal of Applied Social Psychology, 18*, 699-719.

Hughes, C., & Page, P. (2003). Scientific Basis of Elastic Resistance. In P. Page & T. S. Ellenbecker (Eds.), *The Scientific and Clinical Application of Elastic Resistance* (pp. 2-14). Champaign, Ill: Human Kinetics.

Jacobson, N. S., & Truax, P. (1991). Clinical significance: a statistical approach to defining meaningful change and psychotherapy research. *Journal of Consulting and Clinical Psychology, 59*, 12-19.

Jones, R. J. A., Polman, R. C. J., & Peters, D. M. (2009). Physical self-perceptions of adoelscents in Years 8, 9 and 10 in independent schools, state comprehensive schools and specialist sports colleges in England. *Physical Education & Sport Pedagogy, 14*(2), 109-124.

Kirk, R. E. (1996). Practical significance: a concept whose time has come. *Educational and Psychological Measurement, 56*, 746-759.

Lau, P. W. C., Yu, C. W., Lee, A., & Sung, R. Y. T. (2004). The physiological and psychological effects of resistance training on Chinese obese adolescents. *Journal of Exercise Science and Fitness, 2*(2), 115-120.

Lindwall, M., & Lingren, E. C. (2005). The effects of a 6-month exercise intervention programme on physical self-perceptions and social physique anxiety in non-

physicallly active adolescent Swedish girls. *Psychology of Sport & Exercise, 6*, 643-658.

Lubans, D. R., Foster, C., & Biddle, S. J. H. (2008). A review of mediators of behavior in interventions to promote physical activity among children and adolescents. *Preventive Medicine, 47*, 463-470.

Lubans, D. R., Morgan, P. J., & McCormack, A. (in press). Adolescents and school sport: The relationship between beliefs, social support and physical self-perception. *Physical Education & Sport Pedagogy*, Accepted February 2010.

Lubans, D. R., Sheaman, C., & Callister, R. (2010). Exercise adherence and intervention effects of two school-based resistance training programs for adolescents. *Preventive Medicine, 50*(1), 56–62.

Lubans, D. R., & Sylva, K. (2006). Controlled evaluation of a physical activity intervention for senior school students: Effects of the Lifetime Activity Program. *Journal of Sport & Exercise Psychology*, *28*(3), 252-268.

Malina, R. M. (2006). Weight training in youth-growth, maturation, and safety: an evidence-based review. *Clinical Journal of Sports Medicine, 16*(6), 478-487.

Markula, P. (1995). Firm but shapely, fit but sexy, strong but thin. The postmodern aerobicizing female bodies. *Sociology of Sport Journal, 12*, 424-453.

Marsh, H. W. (1990). A multidimensional, hierarchical model of self-concept: Theoretical and empirical justification. *Educational Psychology Review, 2*, 77-172.

Marsh, H. W., & Redmayne, R. S. (1994). A multidimensional physical self-concept and its relations to multiple components of physical fitness. *Journal of Sport & Exercise Psychology, 16*(1), 43-55.

Moon, J. R., Tobkin, S. E., Roberts, M. D., Dalbo, V. J., Kerksick, C. M., Bemben, M. G., et al. (2008). Total body water estimations in healthy men and women using bioimpedance spectroscopy: a deuterium oxide comparison. *Nutrition & Metabolism, 5*(1), 7.

Nielsen, B. M., Dencker, M., Ward, L., Linden, C., Thorsson, O., Karlsson, M. K., et al. (2007). Prediction of fat-free body mass from bioelectrical impedance among 9- to 11-year-old Swedish children. *Diabetes, obesity & metabolism, 9*(9), 521-539.

Noar, S. M., Melissa Chabota, M., & Zimmerman, R. S. (2008). Applying health behavior theory to multiple behavior change: Considerations and approaches. *Preventive Medicine, 46*(3), 275-280.

Raudsepp, L., & Hannus, A. (2002). Children's and adolescents' physical self-perceptions as related to moderate to vigorous physical activity and physical fitness. *Pediatric Exercise Science, 14* (1), 97-106.

Robertson, R. J., & Noble, B. J. (1997). Perception of physical exertion: Methods, mediators and applications. *Exercise & Sport Sciences Reviews, 25*(1), 407-452.

Sadres, E., Eliakim, A., Constantini, N., Lidor, R., & Falk, B. (2001). The effect of long-term resistance training on anthropometric measures, muscle strength, and self concept in pre-pubertal boys *Pediatric Exercise Science, 13*(4), 357-372.

Santrock, J. W. (2005). *Adolesence*. Boston: McGraw-Hill.

Scharfetter, H., Brunner, P., Mayer, M., Brandstätter, B., & Hinghofer-Szalkay, H. (2005). Fat and hydration monitoring by abdominal bioimpedance analysis:

data interpretation by hierarchical electrical modeling. *IEEE transactions on bio-medical engineering, 52*(6), 975-982.

Schneider, M., Fridlund Dunton, G., & Cooper, D. M. (2008). Physical activity and physical self-concept among sedentary adolescent females: An intervention study. *Psychology of Sport & Exercise, 9*, 1-14.

Shilts, M. K., Horowitz, M., & Townsend, M. S. (2004). Goal setting as a strategy for dietary and physical activity behavior change: A review of the literature. *American Journal of Health Promotion, 19*(2), 81-93.

Spence, J., McGannon, K., & Poon, P. (2005). The effect of exercise on global self-esteem. *Journal of Sport & Exercise Psychology, 27*, 311-334.

Stratton, G., Jones, M., Fox, K. R., Tolfrey, K., Harris, J., Maffulli, N., et al. (2004). BASES position statement on guidelines for resistance exercise in young people. *Journal of Sports Sciences, 22*, 383-390.

U.S. Department of Health & Human Services. (2008). *2008 Physical Activity Guidelines for Americans*. Washington, D.C.: U.S. Department of Health & Human Services.

Weiss, M. R., & Ebbeck, V. (1996). Self-esteem and perceptions of competence in youth sports. In R. M. Malina (Ed.), *The encyclopedia of sports medicine, Volume IV: The child and adolescent athlete* (pp. 364-382). Oxford: Blackwell Science Ltd.

Whitehead, J. R. (1995). A study of children's physical self-perceptions using an adapted physical self-perception profile questionnaire. *Pediatric Exercise Science, 7*, 132-151.

Williams, J. G., Eston, R. G., & Stretch, C. (1991). Use of the rating of perceived exertion to control exercise intensity in children. *Pediatric Exercise Science, 3*(1), 21-27.

Figure 1. Standardised parameter estimates of resistance training scales.

(This figure depicts the standardised parameter estimates of the resistance training self-efficacy and outcome expectation scales).