Abstract

The primary aim of this study was to investigate gender differences in the relationship between muscular strength, body composition, and physical self-perception in adolescents. Participants (n=106, age 15.0 ± 0.7 years, 51% boys) completed the following assessments: height and weight, bio-impedance analysis (body fat %), muscular strength (1RM bench press and leg press), and the Children’s Physical Self-Perception Profile. Bivariate correlations were examined and mediation analysis was used to explore if physical self-perception sub-domains mediated the relationship between muscular strength/adiposity and overall physical self-worth. Among boys, physical self-worth was associated with absolute total strength ($r=0.36, p<0.01$), but not with body fat % ($r=-0.11, p=0.44$), or relative total strength ($r=0.21, p=0.13$). In adolescent girls, physical self-worth was associated with body fat % ($r=-0.42, p<0.01$), relative total strength ($r=0.40, p<0.01$) but not absolute total strength ($r=0.07, p=0.62$). In boys, perceived physical strength mediated the relationship between absolute muscular strength and physical self-worth. Relative muscular strength was not associated with perceived strength ($p > 0.05$) in girls and the test of the mediated effect was non-significant ($p > 0.05$). Perceived body attractiveness was found to mediate the relationship between body fat % and physical self-worth among boys and girls. Physical self-worth is associated with different components of health-related fitness in adolescent girls and boys. Mediation analysis can be used to provide insights into the complex interrelationships between variables.

Key words: Muscular strength; body image; physical self-perception; physical fitness
Adolescents in many economically developed nations do not achieve the necessary levels of physical activity to accrue the associated health benefits and improving our understanding of adolescents’ motives for physical activity has become an important public health priority. Weiss and Ebbeck, building on Harter’s Competence Motivation Theory, presented a model for understanding physical activity motivation in youth that illustrated the importance of global self-esteem for physical activity behaviour. In their model, perceived competence and social support are considered to be determinants of self-esteem, and enjoyment and physical activity behaviour are the outcomes. Self-esteem has long occupied a central role in the explanation of human behaviour and is generally considered to be both a multi-dimensional (physical, social, academic) and hierarchical construct. As physical self-perceptions have been linked to physical activity behaviour in youth populations, the development of positive self-perceptions among adolescents may be an important foundation for a physically active lifestyle.

Physical self-worth is also a multi-dimensional and hierarchical construct comprising of sub-domain-specific self-perceptions (e.g. sport competence, body attractiveness, physical condition, physical strength). The extent to which these physical self-perception sub-domains might impact on an adolescent’s physical self-worth is dependent on the value placed on each sub-domain, which is likely to differ by gender. For adolescent girls in many Western societies, great value is placed on conforming to the cultural ideal of the thin body, and images and messages portraying standards for female beauty shape the perceptions girls have of their own bodies. Internalisation of the “thin ideal” among girls begins as early as 9-years of age, and adolescent girls’ perceived failure to achieve a culturally determined body shape is associated with low global self-esteem. It is therefore not surprising that longitudinal research indicates that perceived body
attractiveness appears to be the physical self-perception sub-domain most predictive of
physical self-worth among adolescent females\(^8\). In contrast, to be masculine in numerous
cultures is to project a physical presence of power and strength, and the sporting arena has
been identified as a stage for young males to express their masculinity\(^{15}\). The pursuit of
masculinity and physical strength have been observed among boys and men, from both
Western and non-Western cultures, more so than among women\(^{16}\). Consequently,
perceptions of physical strength have been shown to relate more strongly to physical self-
worth among adolescent males compared with females\(^{17}\) and, of the physical self-perception
sub-domains, perceived physical strength holds the weakest prospective association with
physical self-worth among adolescent females\(^8\). Gender, therefore, seems to be influential in
shaping the associations between physical self-perception sub-domains and physical self-
worth during adolescence.

A potential correlate of an adolescents’ perceived physical competence and self-
worth is their actual competence, ability or status in physical activity-related sub-domains\(^9\),
such as their health-related fitness (i.e. cardio-respiratory fitness, muscular endurance,
flexibility, body composition). While previous studies have examined the interrelationships
between physical activity, adiposity, cardio-respiratory fitness and physical self-perceptions
in adolescents\(^{18-19}\), the role of actual muscular strength in the formation of adolescents’
physical self-perceptions has not yet been investigated. In addition, there is limited evidence
to indicate whether health-related fitness characteristics like adiposity or muscular strength
exert their influence on adolescents’ physical self-worth directly, or whether corresponding
physical self-perception sub-domains mediate these relationships. Better understanding the
associations between health-related fitness characteristics and physical self-perceptions, and
the role of gender in such associations, would assist in the design of targeted interventions
to enhance adolescents’ physical self-perceptions.
The primary aim of this study was to investigate gender differences in the relationship between muscular strength, body composition, and physical self-perceptions in adolescents. A secondary aim was to explore if physical self-perception sub-domains mediated the relationship between muscular strength, adiposity and physical self-worth at the domain level. Due to the aforementioned value placed on muscularity among adolescent males, we hypothesized that muscular strength would be positively related to physical self-worth among males, and that this relationship would be mediated by perceived strength. Alternatively, because of the importance placed on the thin female body in western culture, we hypothesized that adiposity would be negatively related to physical self-worth among females, and that perceived body attractiveness would mediate this relationship.

**Methods**

Approval for the study was obtained from the University of Newcastle Research Ethics Committee and the school principal from one secondary school in Newcastle, New South Wales (NSW), Australia. Eligible participants were secondary school students at the study school in years 9 and 10 participating in a university designed, school-based physical activity program. Data from baseline assessments are reported in this paper (August 2008 to June 2009). Assessments were completed by trained research assistants at the study school. Participants were asked to refrain from physical activity before testing and to maintain their normal hydration patterns.

*Height and weight:* Height (PEb7) and weight (Seca 770, Wedderburn) were measured using the standard protocols and body mass index (BMI) was calculated (weight[kg]/height[m]^2). The International Obesity Task Force (IOTF) cut-points.
were applied to the data to define overweight and obesity\textsuperscript{20} and age- and sex-adjusted
classification, and age- and sex-adjusted standardized scores (z-scores) were calculated.

\textit{Body composition.} The Imp\textsuperscript{TM} SFB7 tetra polar bioelectrical impedance (BIA) analyzer was used to determine level of adiposity (body fat \%). Tetra-polar BIA has been found to accurately predict whole body fat free mass (dual-energy X-ray absorptiometry) in youth ($r^2 = 0.95$)\textsuperscript{21}.

\textit{Muscular strength.} Maximal muscular strength of the upper and lower body was assessed using a supine bench press and incline seated leg press, respectively. Strength was assessed using a progressive repetition maximal lift (1RM) protocol, which includes two phases and has good test-retest reliability ($r = 0.93$)\textsuperscript{22}. In the familiarization phase, the instructors demonstrated the lift and then the participants were instructed on correct form and breathing and given 2-3 practice lifts with a light bar or no weights. In the testing phase, the weights were increased until the subject could no longer lift the weight, despite verbal encouragement on two consecutive attempts 90 seconds apart. The scores were added together to provide a measure of total strength. Relative strength was calculated by dividing absolute strength by body weight.

\textit{Children’s Physical Self-Perception Profile (C-PSPP):} The C-PSPP\textsuperscript{10} was used in the current study to provide a measure of physical self-esteem and includes five subscales, each consisting of six items. The C-PSPP employs an alternate choice format and 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 internal consistencies of the subscales in the study sample were as follows: physical...
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self-worth ($\alpha = 0.88$), sports competence ($\alpha = 0.86$), physical condition ($\alpha = 0.82$),

body attractiveness ($\alpha = 0.86$), and strength ($\alpha = 0.91$).

Data were analyzed using the Statistical Package for the Social Sciences (SPSS, version 16, SPSS Inc., Chicago, Ill, USA) and alpha levels were set at $p < 0.05$. All data were assessed for normality and satisfied the criteria. Independent samples t-tests were used to compare gender differences for all relevant variables.

Bivariate correlation and mediation analyses were used to examine the relationships between body composition, muscular strength and physical self-perception for boys and girls separately.

Mediation analyses should be driven by theory and consistent with previous research into adolescents’ physical self-perceptions, we hypothesized a hierarchical relationship between specific sub-domains and physical self-worth in adolescents. Mediation analyses were conducted to test the following hypotheses: (1) Does perceived strength mediate the relationship between muscular strength and overall physical self-worth? (2) Does perceived body attractiveness mediate the relationship between adiposity and overall physical self-worth? Both hypotheses were tested separately in boys and girls. A product-of-coefficients test was used because it has good statistical power in small samples and the current study was sufficiently powered to detect medium to large mediation effects. To test our hypotheses the following regression models were calculated. First, the relationship between muscular strength/adiposity and the hypothesized mediators (i.e. perceived strength and body attractiveness) was assessed ($\alpha$). Second, muscular strength/adiposity and hypothesized mediators were entered into a regression model predicting physical self-worth ($\beta$). Third, the mediated effect was calculated by multiplying $\alpha$ and $\beta$. In the final step, asymmetric confidence intervals were used to test the significance of the
product of coefficients ($\alpha \beta$) using Mackinnon et al.’s PRODCLIN (PRODuct Confidence Limits for INdirect effects) program. If zero lies outside the confidence interval, then the mediated effect is statistically significant$^{26}$.

**Results**

Participants were 52 girls (mean age 14.9 ± 0.7 years) and 54 boys (mean age 15.0 ± 0.6 years) (Table 1). Most of the participants spoke English as their first language and were born in Australia. Seventeen participants (16% of study sample) were classified as overweight or obese (7 girls and 10 boys) based on the IOTF guidelines. Boys were significantly heavier ($p < 0.001$), taller ($p < 0.001$), and leaner ($p < 0.001$), than girls in the study sample. Boys were generally stronger than girls in the study sample; however, the difference between boys and girls for relative lower body strength was not statistically significant ($p > 0.05$).

Among boys, physical self-worth was not associated with body fat % ($r = -0.11, p = 0.44$) or relative total strength ($r = 0.21, p = 0.13$). However, physical self-worth was associated with absolute total strength ($r = 0.36, p < 0.01$) and the other physical self-perception sub-domains. In adolescent girls, physical self-worth was associated with body fat % ($r = -0.42, p < 0.01$), relative total strength ($r = 0.40, p < 0.01$), but not absolute total strength ($r = 0.07, p = 0.62$).

In boys, absolute muscular strength was associated with perceived physical strength ($p < 0.001$), which mediated the cross-sectional relationship between strength and physical self-worth (Table 2). Relative muscular strength was not associated with perceived strength ($p > 0.05$) in girls and the test of the mediated effect was non-significant ($p > 0.05$). Perceived body attractiveness was found to mediate the relationship between body fat % and physical self-worth in girls ($p < 0.05$). Although the relationship between body fat and physical self-worth among boys was non-
significant in the bivariate correlation ($p > 0.05$), results from the mediation analysis showed that perceived body attractiveness mediated the relationship ($p < 0.05$).

**Discussion**

The primary aim of this study was to investigate gender differences in the relationship between muscular strength, body composition, and physical self-perception in adolescents. In the current study, absolute muscular strength was associated with physical self-worth in boys, with perceived strength mediating this relationship. Adiposity was inversely related to physical self-worth in adolescent girls and perceived body attractiveness mediated this relationship. Interestingly, relative strength but not absolute strength was associated with physical self-worth in girls.

While previous studies have explored the relationship between physical self-perception, physical activity, cardio-respiratory fitness, and adiposity in adolescents, to the authors’ knowledge, this is the first study to examine the relationship between physical self-perception and muscular strength in youth using maximal strength tests. Boys’ perceived strength and physical self-worth were only associated with their absolute strength, indicating that boys’ physical self-perceptions were related to less realistic strength expectations than girls. Thus, in this sample, boys with high muscular strength relative to their body size, but with smaller bodies, exhibited less positive physical self-perceptions than their peers with similar relative strength but larger bodies. An alternate explanation for this finding is that smaller boys have a reduced sense of self-worth, regardless of their relative strength. Due to the importance of muscularity and physical strength among boys and men from both Western and non-Western cultures, educating adolescents about body types and their potential for training effects might help them to base their physical self-perceptions on realistic standards rather than unachievable goals.
In a previous study, Raustorp and colleagues\textsuperscript{28} found that the relationship between physical self-perception and BMI was stronger in girls, than in boys. Similarly, Duncan and colleagues\textsuperscript{19} found that the association between body dissatisfaction and adiposity was higher among girls. In the current study adiposity and perceived body attractiveness were important predictors of physical self-worth in girls. Level of adiposity was not significantly associated with physical self-worth or perceived body attractiveness in the bivariate correlations among adolescent boys. But the PRODCLIN test of mediation indicated that the relationship between adiposity and physical self-worth was mediated through perceived body attractiveness. Without conducting a mediation analysis, the assumption would be that adiposity is not associated with physical self-worth in boys. Although muscular strength explained more of the variance in physical self-worth than body fat, it appears that level of adiposity also contributes to physical self-worth in adolescent boys.

The differences between boys and girls in the relationships between muscular strength, adiposity and physical self-perceptions are important for physical training program facilitators aiming to promote physical self-perceptions among adolescents, and are likely the consequence of the value placed on the lean, thin female body in Western Society\textsuperscript{14}. As perceived body attractiveness and physical self-worth are associated with key psychological and behavioural outcomes among adolescent girls, including their global self-worth or self-esteem\textsuperscript{8}, as well as their physical activity participation\textsuperscript{8}, these findings are worthy of further examination in longitudinal and experimental studies. Such studies should examine changes in adolescent girls’ adiposity and relative strength, and their effect on subsequent changes in physical self-perceptions and physical activity. In designing physical activity programs for
adolescent girls, it might also be fruitful to target improvements in both relative
strength and reductions in adiposity, to enhance physical self-perceptions and
physical activity participation.

The strengths of this study include the evaluation of a range of health-related
fitness characteristics including maximal measures of muscular strength. Few studies
have examined differences in relationships between measures of health-related fitness
and physical self-perceptions by gender among adolescents. Mediation analysis has
also rarely been applied in this area. This analysis indicated that physical self-
perception sub-domains mediated the relationships between muscular strength or
adiposity and physical self-worth, which also differed by gender among adolescents.
As the current analyses were cross-sectional and were conducted among a small-sized
and relatively homogenous sample, prospective longitudinal or experimental studies
with larger sample sizes are needed to test the causal nature of the associations found
in this preliminary investigation. Although we did not assess Tanner stage in the
current study, it is important to note that variations in physical maturity among
adolescents may influence the relationship between measures of physical fitness and
self-perceptions in this group. While early maturity may have a negative effect on
self-perception among adolescent girls, it may have the opposite effect for adolescent
boys.

Conclusion

Muscular strength has been identified as an important determinant of health in
young people and guidelines to improve muscular strength in children and
adolescents are now included in the physical activity recommendations for youth.
Considering the importance of physical self-perceptions in the prediction of health
behaviours, including physical activity, strategies to engage adolescents in activities
to improve muscular strength and reduce adiposity are warranted.

Practical implications

• Gender differences should be considered when seeking to enhance physical
  self-perceptions in adolescents.

• Physical education and exercise environments for adolescents should avoid
  social comparisons and promote self-referencing.

• Mediation analysis can be used to provide insights into the complex
  interrelationships between variables that might not be detected using
  traditional statistical approaches.

Acknowledgements

This project was supported by a University of Newcastle Pilot Grant. The
authors would like to thank Robin Callister, Elroy Aguiar, and Cayenne Sheaman for
their roles in the design and collection of data for this project. We would also like to
thank the school and students for making this study possible.


multidimensional, hierarchical model across gender and grade


### Table 1: Baseline characteristics of participants

<table>
<thead>
<tr>
<th>Variables</th>
<th>Boys (n = 54)</th>
<th>Girls (n = 52)</th>
<th>Total (N = 106)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (yr)</td>
<td>15.0 (0.6)</td>
<td>14.9 (0.9)</td>
<td>14.9 (0.7)</td>
</tr>
<tr>
<td>English/non-English (n)¹</td>
<td>52/2</td>
<td>52/0</td>
<td>104/2</td>
</tr>
<tr>
<td>Australia/other (n)²</td>
<td>53/1</td>
<td>52/0</td>
<td>105/1</td>
</tr>
<tr>
<td><strong>Anthropometrics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.72 (0.09)</td>
<td>1.64 (0.06)</td>
<td>1.68 (0.09)***</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>65.2 (12.5)</td>
<td>57.6 (8.2)</td>
<td>61.4 (11.2)***</td>
</tr>
<tr>
<td>BMI z-score</td>
<td>0.59 (0.81)</td>
<td>0.37 (0.74)</td>
<td>0.48 (0.78)</td>
</tr>
<tr>
<td>BIA (% body fat)</td>
<td>14.9 (6.1)</td>
<td>24.6 (6.5)</td>
<td>19.7 (7.9)***</td>
</tr>
<tr>
<td><strong>Muscular fitness</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute upper body strength (kg)</td>
<td>50.2 (13.5)</td>
<td>31.2 (6.0)</td>
<td>40.9 (14.2)***</td>
</tr>
<tr>
<td>Relative upper body strength (kg/kg)</td>
<td>0.77 (0.16)</td>
<td>0.55 (0.12)</td>
<td>0.66 (0.18)***</td>
</tr>
<tr>
<td>Absolute lower body strength (kg)</td>
<td>179.2 (47.2)</td>
<td>146.5 (27.2)</td>
<td>162.9 (41.7)***</td>
</tr>
<tr>
<td>Relative lower body strength (kg/kg)</td>
<td>2.78 (0.69)</td>
<td>2.56 (0.43)</td>
<td>2.67 (0.58)</td>
</tr>
<tr>
<td>Absolute total strength (kg)</td>
<td>229.8 (57.0)</td>
<td>177.7 (28.6)</td>
<td>203.8 (52.0)***</td>
</tr>
<tr>
<td>Relative total strength (kg/kg)</td>
<td>3.55 (0.78)</td>
<td>3.12 (0.47)</td>
<td>3.33 (0.68)**</td>
</tr>
<tr>
<td><strong>Physical self-perception</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical self-worth</td>
<td>2.96 (0.61)</td>
<td>2.75 (0.59)</td>
<td>2.89 (0.61)</td>
</tr>
<tr>
<td>Perceived sport competence</td>
<td>3.07 (0.58)</td>
<td>2.71 (0.59)</td>
<td>2.89 (0.61)**</td>
</tr>
<tr>
<td>Perceived physical condition</td>
<td>3.06 (0.58)</td>
<td>2.79 (0.56)</td>
<td>2.93 (0.58)*</td>
</tr>
<tr>
<td>Perceived body attractiveness</td>
<td>2.61 (0.51)</td>
<td>2.56 (0.67)</td>
<td>2.58 (0.67)</td>
</tr>
<tr>
<td>Perceived physical strength</td>
<td>2.55 (0.70)</td>
<td>2.60 (0.63)</td>
<td>2.57 (0.66)</td>
</tr>
</tbody>
</table>

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*Data are presented as means (standard deviations), unless otherwise indicated.

¹Language spoken at home- English/non-English language

²Country of birth- Australia/other

BMI z-score = body mass index z-score calculated using the IOTF guidelines, Relative strength = absolute strength/body weight; Total strength = upper body + lower body strength

*Significant difference between boys and girls

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Table 2: Path coefficients, confidence levels and significance of the mediated effect of sub-domains on physical self-worth

<table>
<thead>
<tr>
<th>Hypothesized mediators</th>
<th>Unstandardised regression coefficients and confidence intervals</th>
<th>Significance of mediated effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>α (SE)</td>
<td>95% CI</td>
</tr>
<tr>
<td><strong>Boys</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived body attractiveness^a</td>
<td>-0.018 (0.011)</td>
<td>-0.041 to 0.004</td>
</tr>
<tr>
<td>Perceived physical strength^b</td>
<td>0.006 (0.002)***</td>
<td>0.003 to 0.009</td>
</tr>
<tr>
<td><strong>Girls</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived body attractiveness^a</td>
<td>-0.044 (0.013)**</td>
<td>-0.071 to -0.018</td>
</tr>
<tr>
<td>Perceived physical strength^c</td>
<td>0.290 (0.181)</td>
<td>-0.075 to 0.654</td>
</tr>
</tbody>
</table>

Note. *p < 0.05, **p < 0.01, ***p < 0.001

α = estimate of unstandardised regression coefficient of muscular strength/adiposity predicting hypothesized mediators; β = estimate of the unstandardised regression coefficient of the hypothesized mediator predicting physical self-worth with muscular fitness/adiposity in the model; SE = standard error; 95% CI = 95% confidence interval; αβ = product-of-coefficients estimate.

^a Hypothesis tested- the relationship between adiposity (body fat %) and physical self-worth is mediated by perceived body attractiveness

^b Hypothesis tested- the relationship between muscular strength (absolute) and physical self-worth is mediated by perceived physical strength

^c Hypothesis tested- the relationship between muscular strength (relative) and physical self-worth is mediated by perceived physical strength

^d 95% asymmetric confidence intervals of the mediated effect calculated using the PRODCLIN program- if zero is outside of the 95% CIs, the mediated effect is significant at p < 0.05.