1 Abstract

2 The primary aim of this study was to investigate gender differences in the relationship 3 between muscular strength, body composition, and physical self-perception in 4 adolescents. Participants (n=106, age 15.0 ± 0.7 years, 51% boys) completed the 5 following assessments: height and weight, bio-impedance analysis (body fat %), 6 muscular strength (1RM bench press and leg press), and the Children's Physical Self-7 Perception Profile. Bivariate correlations were examined and mediation analysis was 8 used to explore if physical self-perception sub-domains mediated the relationship 9 between muscular strength/adiposity and overall physical self-worth. Among boys, 10 physical self-worth was associated with absolute total strength (r = 0.36, p < 0.01), but 11 not with body fat % (r = -0.11, p = 0.44), or relative total strength (r = 0.21, p = 0.13). In 12 adolescent girls, physical self-worth was associated with body fat % (r = -0.42, p 13 <0.01), relative total strength (r =0.40, p <0.01) but not absolute total strength (r =0.07, 14 p = 0.62). In boys, perceived physical strength mediated the relationship between 15 absolute muscular strength and physical self-worth. Relative muscular strength was not 16 associated with perceived strength (p > 0.05) in girls and the test of the mediated effect 17 was non-significant (p > 0.05). Perceived body attractiveness was found to mediate the 18 relationship between body fat % and physical self-worth among boys and girls. 19 Physical self-worth is associated with different components of health-related fitness in 20 adolescent girls and boys. Mediation analysis can be used to provide insights into the 21 complex interrelationships between variables.

22 Key words: Muscular strength; body image; physical self-perception; physical fitness

23	Adolescents in many economically developed nations do not achieve the
24	necessary levels of physical activity to accrue the associated health benefits ¹ and
25	improving our understanding of adolescents' motives for physical activity has become
26	an important public health priority. Weiss and Ebbeck ² , building on Harter's
27	Competence Motivation Theory ³ , presented a model for understanding physical
28	activity motivation in youth that illustrated the importance of global self-esteem for
29	physical activity behaviour. In their model, perceived competence and social support
30	are considered to be determinants of self-esteem, and enjoyment and physical activity
31	behaviour are the outcomes ⁴ . Self-esteem has long occupied a central role in the
32	explanation of human behaviour ⁵ and is generally considered to be both a multi-
33	dimensional (physical, social, academic) and hierarchical construct ⁶ . As physical self-
34	perceptions have been linked to physical activity behaviour in youth populations ^{7, 8} ,
35	the development of positive self-perceptions among adolescents may be an important
36	foundation for a physically active lifestyle.
37	Physical self-worth is also a multi-dimensional and hierarchical construct comprising
38	of sub-domain-specific self-perceptions (e.g. sport competence, body attractiveness,
39	physical condition, physical strength) ⁵ . The extent to which these physical self-perception
40	sub-domains might impact on an adolescent's physical self-worth is dependent on the value
41	placed on each sub-domain ^{9, 10} , which is likely to differ by gender. For adolescent girls in
42	many Western societies, great value is placed on conforming to the cultural ideal of the thin
43	body, and images and messages portraying standards for female beauty shape the
44	perceptions girls have of their own bodies ¹¹ . Internalisation of the "thin ideal" among girls
45	begins as early as 9-years of age ¹² , and adolescent girls' perceived failure to achieve a
46	culturally determined body shape is associated with low global self-esteem ^{13, 14} . It is
47	therefore not surprising that longitudinal research indicates that perceived body

48 attractiveness appears to be the physical self-perception sub-domain most predictive of physical self-worth among adolescent females⁸. In contrast, to be masculine in numerous 49 cultures is to project a physical presence of power and strength, and the sporting arena has 50 been identified as a stage for young males to express their masculinity¹⁵. The pursuit of 51 52 muscularity and physical strength have been observed among boys and men, from both Western and non-Western cultures, more so than among women¹⁶. Consequently, 53 54 perceptions of physical strength have been shown to relate more strongly to physical selfworth among adolescent males compared with females¹⁷ and, of the physical self-perception 55 56 sub-domains, perceived physical strength holds the weakest prospective association with physical self-worth among adolescent females⁸. Gender, therefore, seems to be influential in 57 58 shaping the associations between physical self-perception sub-domains and physical self-59 worth during adolescence.

60 A potential correlate of an adolescents' perceived physical competence and selfworth is their actual competence, ability or status in physical activity-related sub-domains⁹, 61 62 such as their health-related fitness (i.e. cardio-respiratory fitness, muscular endurance, 63 flexibility, body composition). While previous studies have examined the interrelationships 64 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' 65 66 physical self-perceptions has not yet been investigated. In addition, there is limited evidence 67 to indicate whether health-related fitness characteristics like adiposity or muscular strength 68 exert their influence on adolescents' physical self-worth directly, or whether corresponding 69 physical self-perception sub-domains mediate these relationships. Better understanding the 70 associations between health-related fitness characteristics and physical self-perceptions, and 71 the role of gender in such associations, would assist in the design of targeted interventions 72 to enhance adolescents' physical self-perceptions.

73	The primary aim of this study was to investigate gender differences in the
74	relationship between muscular strength, body composition, and physical self-
75	perceptions in adolescents. A secondary aim was to explore if physical self-
76	perception sub-domains mediated the relationship between muscular strength,
77	adiposity and physical self-worth at the domain level. Due to the aforementioned
78	value placed on muscularity among adolescent males, we hypothesized that
79	muscular strength would be positively related to physical self-worth among males,
80	and that this relationship would be mediated by perceived strength. Alternatively,
81	because of the importance placed on the thin female body in western culture, we
82	hypothesized that adiposity would be negatively related to physical self-worth
83	among females, and that perceived body attractiveness would mediate this
84	relationship

85 Methods

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86 Approval for the study was obtained from the University of Newcastle 87 Research Ethics Committee and the school principal from one secondary school in 88 Newcastle, New South Wales (NSW), Australia. Eligible participants were secondary 89 school students at the study school in years 9 and 10 participating in a university 90 designed, school-based physical activity program. Data from baseline assessments are 91 reported in this paper (August 2008 to June 2009). Assessments were completed by 92 trained research assistants at the study school. Participants were asked to refrain from 93 physical activity before testing and to maintain their normal hydration patterns. 94 Height and weight: Height (PEb7) and weight (Seca 770, Wedderburn) were 95 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

97 were applied to the data to define overweight and obesity²⁰ and age- and sex-adjusted
98 standardized scores (*z*-scores) were calculated.

99 Body composition. The ImpTM SFB7 tetra polar bioelectrical impedance (BIA) 100 analyzer was used to determine level of adiposity (body fat %). Tetra-polar BIA has 101 been found to accurately predict whole body fat free mass (dual-energy X-ray 102 absorptiometry) in youth $(r^2 = 0.95)^{21}$.

103 *Muscular strength*. Maximal muscular strength of the upper and lower body 104 was assessed using a supine bench press and incline seated leg press, respectively. 105 Strength was assessed using a progressive repetition maximal lift (1RM) protocol, which includes two phases and has good test-retest reliability $(r = 0.93)^{22}$. In the 106 107 familiarization phase, the instructors demonstrated the lift and then the participants 108 were instructed on correct form and breathing and given 2-3 practice lifts with a light 109 bar or no weights. In the testing phase, the weights were increased until the subject 110 could no longer lift the weight, despite verbal encouragement on two consecutive 111 attempts 90 seconds apart. The scores were added together to provide a measure of 112 total strength. Relative strength was calculated by dividing absolute strength by body 113 weight.

114 *Children's Physical Self-Perception Profile (C-PSPP):* The C-PSPP¹⁰ was 115 used in the current study to provide a measure of physical self-esteem and includes 116 five subscales, each consisting of six items. The C-PSPP employs an alternate choice 117 format and participants must first decide which of the two statements best describes 118 them and then choose whether the statement is 'sort of true' or 'really true' for them. 119 Each item is scored from 1 (*low-self-perception*) to 4 (*high self-perception*). The 120 internal consistencies of the subscales in the study sample were as follows: *physical*

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121 self-worth (\alpha = 0.88), sports competence (\alpha = 0.86), physical condition (\alpha = 0.82),
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122 *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.

130 Mediation analyses should be driven by theory and consistent with previous research into adolescents' physical self-perceptions^{5, 23, 24}, we hypothesized a 131 132 hierarchical relationship between specific sub-domains and physical self-worth in 133 adolescents. Mediation analyses were conducted to test the following hypotheses: (1) 134 Does perceived strength mediate the relationship between muscular strength and 135 overall physical self-worth? (2) Does perceived body attractiveness mediate the 136 relationship between adiposity and overall physical self-worth? Both hypotheses were 137 tested separately in boys and girls. A product-of-coefficients test was used because it 138 has good statistical power in small samples and the current study was sufficiently powered to detect medium to large mediation effects²⁵. To test our hypotheses the 139 140 following regression models were calculated. First, the relationship between muscular 141 strength/adiposity and the hypothesized mediators (i.e. perceived strength and body attractiveness) was assessed (α). Second, muscular strength/adiposity and 142 143 hypothesized mediators were entered into a regression model predicting physical self-144 worth (β). Third, the mediated effect was calculated by multiplying α and β . In the 145 final step, asymmetric confidence intervals were used to test the significance of the

- 146 product of coefficients ($\alpha\beta$) using Mackinnon et al.'s PRODCLIN (PRODuct
- 147 Confidence Limits for INdirect effects) program. If zero lies outside the confidence
- 148 interval, then the mediated effect is statistically significant²⁶.
- 149 **Results**

150 Participants were 52 girls (mean age 14.9 ± 0.7 years) and 54 boys (mean age 151 15.0 ± 0.6 years) (Table 1). Most of the participants spoke English as their first 152 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 153 154 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 155 156 the study sample; however, the difference between boys and girls for relative lower 157 body strength was not statistically significant (p > 0.05).

158 Among boys, physical self-worth was not associated with body fat % (r = -

159 0.11, p = 0.44) or relative total strength (r = 0.21, p = 0.13). However, physical self-

160 worth was associated with absolute total strength (r = 0.36, p < 0.01) and the other

161 physical self-perception sub-domains. In adolescent girls, physical self-worth was

162 associated with body fat % (r = -0.42, p < 0.01), relative total strength (r = 0.40, p < 0.01)

163 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 nonsignificant (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-

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171 significant in the bivariate correlation (p > 0.05), results from the mediation analysis
172 showed that perceived body attractiveness mediated the relationship (p < 0.05).
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173 Discussion

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174 The primary aim of this study was to investigate gender differences in the 175 relationship between muscular strength, body composition, and physical self-176 perception in adolescents. In the current study, absolute muscular strength was 177 associated with physical self-worth in boys, with perceived strength mediating this 178 relationship. Adiposity was inversely related to physical self-worth in adolescent girls 179 and perceived body attractiveness mediated this relationship. Interestingly, relative 180 strength but not absolute strength was associated with physical self-worth in girls. 181 While previous studies have explored the relationship between physical selfperception, physical activity, cardio-respiratory fitness, and adiposity in adolescents⁸, 182 ^{19, 27}, to the authors' knowledge, this is the first study to examine the relationship 183 184 between physical self-perception and muscular strength in youth using maximal 185 strength tests. Boys' perceived strength and physical self-worth were only associated 186 with their absolute strength, indicating that boys' physical self-perceptions were 187 related to less realistic strength expectations than girls. Thus, in this sample, boys 188 with high muscular strength relative to their body size, but with smaller bodies, 189 exhibited less positive physical self-perceptions than their peers with similar relative 190 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 191

193 Western and non-Western cultures¹⁶, educating adolescents about body types and

the importance of muscularity and physical strength among boys and men from both

194 their potential for training effects might help them to base their physical self-

195 perceptions on realistic standards rather than unachievable goals.

196	In a previous study, Raustorp and colleagues ²⁸ found that the relationship
197	between physical self-perception and BMI was stronger in girls, than in boys.
198	Similarly, Duncan and colleagues ¹⁹ found that the association between body
199	dissatisfaction and adiposity was higher among girls. In the current study adiposity
200	and perceived body attractiveness were important predictors of physical self-worth in
201	girls. Level of adiposity was not significantly associated with physical self-worth or
202	perceived body attractiveness in the bivariate correlations among adolescent boys.
203	But the PRODCLIN test of mediation indicated that the relationship between
204	adiposity and physical self-worth was mediated through perceived body
205	attractiveness. Without conducting a mediation analysis, the assumption would be
206	that adiposity is not associated with physical self-worth in boys. Although muscular
207	strength explained more of the variance in physical self-worth than body fat, it
208	appears that level of adiposity also contributes to physical self-worth in adolescent
209	boys.

210 The differences between boys and girls in the relationships between muscular 211 strength, adiposity and physical self-perceptions are important for physical training 212 program facilitators aiming to promote physical self-perceptions among adolescents, 213 and are likely the consequence of the value placed on the lean, thin female body in Western Society¹⁴. As perceived body attractiveness and physical self-worth are 214 215 associated with key psychological and behavioural outcomes among adolescent girls, including their global self-worth or self-esteem⁸, as well as their physical activity 216 participation⁸, these findings are worthy of further examination in longitudinal and 217 218 experimental studies. Such studies should examine changes in adolescent girls' 219 adiposity and relative strength, and their effect on subsequent changes in physical 220 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.

224 The strengths of this study include the evaluation of a range of health-related 225 fitness characteristics including maximal measures of muscular strength. Few studies 226 have examined differences in relationships between measures of health-related fitness 227 and physical self-perceptions by gender among adolescents. Mediation analysis has 228 also rarely been applied in this area. This analysis indicated that physical self-229 perception sub-domains mediated the relationships between muscular strength or 230 adiposity and physical self-worth, which also differed by gender among adolescents. 231 As the current analyses were cross-sectional and were conducted among a small-sized 232 and relatively homogenous sample, prospective longitudinal or experimental studies 233 with larger sample sizes are needed to test the causal nature of the associations found 234 in this preliminary investigation. Although we did not assess Tanner stage in the 235 current study, it is important to note that variations in physical maturity among 236 adolescents may influence the relationship between measures of physical fitness and 237 self-perceptions in this group. While early maturity may have a negative effect on 238 self-perception among adolescent girls, it may have the opposite effect for adolescent 239 boys.

240 Conclusion

Muscular strength has been identified as an important determinant of health in young people²⁹ and guidelines to improve muscular strength in children and adolescents are now included in the physical activity recommendations for youth³⁰. Considering the importance of physical self-perceptions in the prediction of health

245 behaviours, including physical activity, strategies to engage adolescents in activities

to improve muscular strength and reduce adiposity are warranted.

247 **Practical implications**

248	• Gender differences should be considered when seeking to enhance physical
249	self-perceptions in adolescents.
250	• Physical education and exercise environments for adolescents should avoid
251	social comparisons and promote self-referencing.
252	• Mediation analysis can be used to provide insights into the complex
253	interrelationships between variables that might not be detected using
254	traditional statistical approaches.
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258	their roles in the design and collection of data for this project. We would also like to

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Table 1: Baseline characteristics of participants 352

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

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

¹Language spoken at home- English/non-English language ²Country of birth- Australia/other

354 355 356 357 358 359 360 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

Table 2: Path coefficients, confidence levels and significance of the mediated effect of sub-domains on physical self-worth 361

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Hypothesized mediators	Unstandardised regression coefficients and confidence intervals				Significance of mediated effect	
	α (SE)	95% CI	β (SE)	95% CI	αβ	95% CI ^d
Boys						
Perceived body attractiveness ^a	-0.018 (0.011)	-0.041 to 0.004	0.677 (0.148)***	0.379 to 0.975	-0.0136	-0.0297 to -0.0005*
Perceived physical strength ^b	0.006 (0.002)***	0.003 to 0.009	0.507 (0.118) ***	0.269 to 0.745	0.0030	0.0001 to 0.0052*
Girls						
Perceived body attractiveness ^a	-0.044 (0.013)**	-0.071 to -0.018	0.653 (0.085)***	0.482 to 0.842	-0.0260	-0.0416 to -0.0125*
Perceived physical strength ^c	0.290 (0.181)	-0.075 to 0.654	0.372 (0.115)**	0.140 to 0.604	-0.1073	-0.0251 to 0.2685

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

365 α = estimate of unstandardised regression coefficient of muscular strength/adiposity predicting hypothesized mediators; β = estimate of the unstandardised regression

366 coefficient of the hypothesized mediator predicting physical self-worth with muscular fitness/adiposity in the model; SE = standard error; 95% CI = 95% confidence interval; $\alpha\beta$ = product-of-coefficients estimate.

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

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

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

371 ^d95% asymmetric confidence intervals of the mediated effect calculated using the PRODCLIN program- if zero is outside of the 95% CIs, the mediated effect is

372 significant at p < 0.05.