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Title: Physical activity and physical self-concept in youth: Systematic review and meta-analysis

Running title: Physical activity and physical self-concept in young people

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Key Points

- The results of this meta-analysis indicate a medium effect size relationship between general physical self-concept, perceived competence and perceived fitness and physical activity in young people.
- General physical self-concept, perceived competence and perceived fitness may act as both determinants and outcomes of physical activity behaviour in youth.
- Strategies to enhance physical self-perceptions in children and adolescents may assist in efforts to promote physical activity.

Abstract

Background:

Objective: The primary aim of this systematic review and meta-analysis was to determine the strength of associations between physical activity and physical self-concept (general and sub-domains) in children and adolescents. The secondary aim was to examine potential moderators of the association between physical activity and physical self-concept.

Methods: A systematic search of six electronic databases (MEDLINE, CINAHL, SPORTDiscus, ERIC, Web of Science and Scopus) with no date restrictions was conducted. Random effects meta-analyses with correction for measurement were employed. The associations between physical activity and general physical self-concept and sub-domains were explored. A risk of bias assessment was conducted by two reviewers.

Results: The search identified 64 studies to be included in the meta-analysis. 33 studies addressed multiple outcomes of general physical self-concept: 28 studies examined general physical self-concept, 59 examined perceived competence, 25 examined perceived fitness, and 55 examined perceived appearance. Perceived competence was most strongly associated with physical activity ($r = 0.30$, 95% CI= 0.24 to 0.35, $p < 0.001$), followed by perceived fitness ($r = 0.26$, 95% CI= 0.20 to 0.32, $p < 0.001$), general physical self-concept ($r = 0.25$, 95% CI= 0.16 to 0.34, $p < 0.001$) and perceived physical appearance ($r = 0.12$, 95% CI= 0.08 to 0.16, $p < 0.001$). Sex was a significant moderator for general physical self-concept ($p < 0.05$) and age was a significant moderator for perceived appearance ($p \leq 0.01$) and perceived competence ($p < 0.05$). No significant moderators were found for perceived fitness.

Conclusion: Overall, a significant association has been consistently demonstrated between physical activity and physical self-concept and its various sub-domains in children and

adolescents. Age and sex are key moderators of the association between physical activity and physical self-concept.

1 Introduction

The physical health benefits of physical activity are extensive and include reduced risk of coronary heart disease, type II diabetes, some cancers and osteoporosis as well as improved physical fitness and bone strength[1, 2]. In addition, participation in physical activity may improve psychological health and help prevent and treat the development of mental health disorders such as depression and anxiety[3-5]. Mental health disorders represent a significant public health burden[6, 7], yet mental health is not only the absence of a mental disorder, but a state of psychological well-being in which individuals realise their own ability and potential[8]. The self-concept construct is vital to psychological well-being[9] and is the term used to describe an individual's awareness of their qualities and limitations [10]. Individuals who feel good about themselves and their abilities are resilient to the challenges of life, and self-concept facilitates other aspects of well-being including happiness, motivation, and anxiety[9]. A hierarchical organisation of general self-concept has been posited by Shavelson and colleagues [10], with general self-concept at the apex that includes academic and non-academic sub-domains. Academic self-concept consists of subject specific facets of self (e.g., English, history and mathematics)[11], while the non-academic sub-domain is further divided into social, emotional and physical self-concepts. Physical self-concept (sometimes referred to as physical self-perceptions) is then separated into perceived physical ability and perceived physical appearance[10].

Although known by different names, perceived physical ability (or competence) is considered to be a central determinant of behaviour and is included in prominent social cognitive theories including, competence motivation theory (perceived competence) [12], self-determination theory (competence) [13], social cognitive theory (self-efficacy) [14] and theory of planned behaviour (perceived behavioural control) [15]. In the physical activity domain, perceived competence is generally operationalized as confidence to perform sport

and outdoor games[16], while perceived behavioural control and self-efficacy are defined as confidence to overcome barriers to participation. Self-efficacy, perceived competence and perceived behavioural control are three of the most commonly measured psychological correlates of physical activity and there is evidence for their utility as determinants of behaviour[17-20]. Indeed, in a recent review of reviews, Bauman and colleagues[17] described health status and self-efficacy as the “clearest correlates” of physical activity in adults. The same authors concluded that perceived behavioural control and self-efficacy were the strongest psychological determinants of physical activity in adolescents, but did not find sufficient evidence that perceived competence was a determinant of behaviour.

In contrast to social cognitive models, the exercise and self-esteem model (EXSEM)[21], was developed to explore the pathways by which self-esteem is influenced by physical training. Based on Shavelson’s hierarchical organisation of general self-concept[10], the model proposes that confidence in one’s abilities to perform specific exercises and sports-related activities generalise to a broader perceived physical competence[22]. Therefore, in this model, self-efficacy to complete specific exercise-related tasks is considered an outcome rather than a determinant of activity. More recently, Stodden and colleagues’ proposed a conceptual model that positioned perceived competence as a mediator of the association between motor skill competence and physical activity[23]. In their model, motor skill competence was considered to be the “primary underlying mechanism that promotes engagement in physical activity”, with perceived competence playing an increasingly important role as children develop the cognitive skills to accurately differentiate between actual and perceived motor competence[24, 25].

In summary, it is not clear if general physical self-concept and sub-domains are outcomes, mediators or moderators of physical activity in young people[26]. Numerous studies have modelled physical self-concept and sub-domains as determinants of physical

activity [27-32], while others have explored the impact of exercise and physical activity programs on physical self-perceptions [33, 34]. However, no previous review has systematically evaluated the evidence for the association between physical activity and physical self-concept in children and adolescents. Providing a summary of existing studies may assist in the design of physical activity interventions and/or provide evidence for the positive effects of physical activity on well-being. Therefore, the primary aim of this systematic review and meta-analysis was to determine the association between physical activity and physical self-concept in young people by reviewing cross-sectional, experimental and longitudinal studies. The secondary aim of this review was to examine potential moderators of the association between physical activity and physical self-concept.

2 Methods

2.1 Eligibility Criteria

A study was considered eligible for this review if it met the following inclusion criteria: (a) study included quantitative assessment of leisure-time physical activity. *Physical activity was defined as ““body movement produced by the skeletal muscles which results in a substantial increase over the resting energy expenditure”*[35]. (b) study included the quantitative assessment of physical self-concept or sub-domains (c) study included a quantitative assessment of the association between physical activity and physical self-concept or sub-domains (d) study participants were school-aged children or adolescents (i.e., aged 4 to 20 years), (e) published full text and peer reviewed. For a study to be included in the meta-analysis it was required to report a correlation coefficient or standardized regression coefficient for the association between physical activity and physical self-concept or sub-domains (studies that did not provide this information but examined the association between physical activity and physical self-concept are included in Electronic Supplementary Material Table S1).

Excluded studies were those which: (a) were published in languages other than English, (b) reported only qualitative data, (c) included participants that were targeted groups from special populations (e.g., people with mental illness, psychiatric disorders, developmental delays and developmental co-ordination or eating disorders) and (d) conference abstracts, dissertations, thesis or non-peer reviewed studies. Finally, studies examining the impact of physical activity programs on physical self-concept or sub-domains were not included if they did not examine the association between changes in physical activity and changes in self-perceptions.

To allow for the aggregation of findings, scales/questionnaires assessing similar constructs of different names were combined in the meta-analyses. For example, ‘perceived appearance’ was presented in different studies as body image, body attractiveness, body esteem. All of these constructs were considered to represent an individual’s assessment of their body size and/or shape, with a higher score representing a more positive self-evaluation. ‘Perceived competence’ was operationally defined as an individual’s assessment of their ability to perform sports and recreational activities. Although related to perceived confidence, ‘perceived fitness’ was operationalized as an individual’s evaluation of their health-related physical fitness. Validation studies of commonly used scales, including the Physical Self-Perception Profile and the Physical Self-Description Questionnaire have demonstrated that perceptions of fitness are unique constructs[36, 37]. Scales assessing the different components of physical fitness (i.e., strength, endurance, flexibility) were combined for the meta-analyses.

2.2 Search Strategy

The literature search was conducted on the 3rd August 2013. Studies were identified through a structured electronic database search of the following databases: MEDLINE, CINAHL, SPORTDiscus, ERIC, Web of Science and Scopus. Search terms included a combination of

key words including: (“Physical activit*” OR exercise OR active OR motor*) AND (adolescence OR teenage OR children OR student OR youth OR boy OR girl) AND (Adoles* OR teen* OR child* OR student OR youth OR boy OR girl OR school OR primary OR elementary OR high OR secondary OR grade) AND (“physical self-concept” OR “physical self-worth” OR perceived competence OR “physical self-perception” OR “physical appearance” OR body image). The strings were further limited to those aged 5-20 years and English language. Only articles published in peer-reviewed journals were considered. The search was executed by MB with the assistance of a professional librarian; reference lists of included studies were manually cross-referenced for possible additional studies. The literature search was conducted in accordance to the standards applicable in the ‘Preferred Reporting Items for Systematic Reviews and Meta-Analysis’ (PRISMA) statement[38](Figure 1). The PRISMA checklist has also been provided (Electronic Supplementary Material Table S2).

2.3 Screening

Two authors (MB and RW) independently assessed each identified study for relevance to the review based on the title, abstract, and full text. In the event of a disagreement, consensus was reached by discussion with a third member (DRL). In the first stage, studies were screened based on title and abstract. Relevant full text articles were searched and evaluated for inclusion. Reference lists of included studies were reviewed for potential papers.

2.4 Data Extraction

The extracted data included authors, country in which the study was conducted, sample (number, age, and sex), study design, location, measure of physical activity, measure of physical self-concept, reliability of tools, outcomes, the intervention (dose and length), year of publication, sample size, number/percentages of males/females (where provided). When

details of mean age were not available, an average was calculated from the age range provided. If a study used more than one physical activity variable, the variable that was most closely aligned with the following definition: “meeting physical activity guidelines during leisure-time” was used[39]. As studies often included multiple statistical analyses (e.g., correlation, multiple regression) the results from the highest level of analysis were used (i.e., multivariate or analyses that accounted for potential confounders were favoured over bivariate analyses). For example, if a study reported both bivariate correlations and multiple regression models, results from the regression models were included in the meta-analysis. If a study reported both longitudinal and cross-sectional results, the longitudinal findings were included in the meta-analysis. This was performed to avoid the double counting of studies and because longitudinal study designs are considered to provide a more robust test of theory[40].

2.5 Analytic Strategies

Meta-analyses were conducted using Comprehensive Meta-Analysis (CMA) Version 2 software program (Englewood, New Jersey, USA)[41]. Effect sizes for each study were calculated before and after correcting for measurement error. Measurement error procedures were based on the reliabilities of the measures as presented in the study or from prior published literature with the same instrument. In cases with single items or where reliabilities were not reported, we used $r_{xy} = 0.70$ based on a conservative, yet acceptable judgment of reliability[42]. In cases where coefficients had already been corrected (e.g., structural equation models), no additional correction procedures were used.

The general aim of a meta-analysis is to provide a more powerful estimate of the effect size (or associations between variables), than what can be achieved in a single study under a specific set of assumptions and conditions. Two types of statistical models are used to create weighted averages when conducting meta-analyses. The fixed effects model

assumes that sampling error accounts for differences in the observed effects, while random effects models produce within study (sampling) and between studies (variance)[43]. Random effects models are considered more appropriate when data are heterogeneous[43, 44], however both models are reported in the current review for comparative purposes. Along with the weighted average effect sizes, we computed the 95% confidence intervals. If the confidence interval does not include zero, then the effect size is statistically significant at the $p < 0.05$ level. Correlations between variables were interpreted as follows: 0.1-0.29 (weak), 0.3-0.49 (moderate) and 0.5-1.0 (strong)[1].

Rosenthal's classic fail safe N [45] and Duval and Tweedie's 'Trim and fill' procedure [46, 47] were used to assess the extent of publication bias. Rosenthal's classic fail safe provides an indication of the number of studies needed with a mean effect of zero before the overall effect would no longer be statistically significant. Alternatively, the 'Trim and fill' procedure selectively removes extreme effect sizes from small studies and replaces them with imputed values to produce a more symmetrical funnel plot, which generates a less biased overall effect size [46, 47].

Separate meta-analyses were carried out for: i) general physical self-concept; ii) perceived competence; iii) perceived fitness, and; iv) perceived appearance. Studies that were separated by sex and or cohort years were treated as separate studies in the meta-analysis. We report the weighted average effect sizes and the 95% confidence intervals. The Q and I^2 statistics were calculated to determine the heterogeneity of the average effect sizes. Q tests are used to determine if the observed variance in effect sizes is no greater than what is expected by sampling error alone, while the I^2 statistic ($I^2 = 100\% \times (Q - df)/Q$) is used to quantify the degree of heterogeneity[48]. The I^2 -value provides the percentage of total variation across studies due to heterogeneity[48] rather than chance. A value of 0% indicates no observed heterogeneity, while larger values indicate increasing heterogeneity. Based on

existing recommendations, I^2 values of 25%, 50% and 75% were considered low, moderate and high, respectively[48].

Subgroup moderator analyses are conducted in meta-analyses to offer an understanding of the strength and/or direction of association between independent and dependent variables[45]. Moderator analyses were also conducted using corrected r 's and random effects models. The following demographic and methodological variables were tested as potential moderators: i) sex (i.e., girls only, boys only and mixed), ii) age (i.e., childhood, early adolescence and late adolescence), iii) study design (i.e., cross-sectional, experimental, and longitudinal). Age was categorised according to definitions from the World Health Organisation, childhood (pre 10 years), early adolescence (10-14) and late adolescence (15-19)[49]. For the moderator analysis, we used Q_B to explore the impact of the categorical variables on the effect size. Q_B is used for testing the differences between effect sizes.

2.6 Synthesis of Studies Not Included in the Meta-analysis

A synthesis of studies not included in the meta-analysis was conducted. Results were coded using the method first employed by Sallies, Prochaska and Taylor (2000). If 0-33.3% of studies reported a significant association, results were classified as having no association (0). If 34-59% of studies reported a significant association or if fewer than four studies were included, the results were classified as being inconsistent/uncertain (?). If >60% of studies find a significant association, the results were classified as positive (+) or negative (-), depending on the direction of the association. If studies employed multiple analyses, only finding from the highest level of analysis (i.e., multivariate) were considered.

2.7 Criteria for Risk of Bias Assessment:

The PRISMA statement recommends that systematic reviews include an evaluation of the methodological risks of bias that may have a bearing on the individual study findings[50].

Potential risk of bias will depend upon the study design and objectives. For example, the Cochrane risk of bias tool[51] consists of five items that are known to influence the estimates of an intervention's effectiveness in randomized controlled trials and includes items relating to sequence generation, allocation concealment blinding, treatment of outcome data and selective outcome reporting. Two authors (MB and RW) independently assessed the 'risk of bias' of the included studies using methodological items and coding. Studies were assessed for 'risk of bias' using criteria adapted from research reviewing the associations between sedentary behaviour and health indicators[52]. A 'risk of bias' score for each study was completed on a 5 point scale by assigning a '✓' if the study met the criteria or a '✗' if the study failed to meet the criteria (Electronic Supplementary Material Table S3).

The studies were examined based on criteria including: (a) Study schools and/or participants were randomly selected from the target population (for experimental studies, the process of randomisation was clearly described and adequately carried out). A '✓' was awarded if the sample was randomly selected from the target population or participants were randomly allocated to conditions for experimental studies. A '✗' was given if convenience sampling was used or if the process of randomisation was not adequately described. (b) Adequate description of baseline study sample (individuals entering the study) for key demographic characteristics (number of participants and their mean age (or age range) and sex). A '✓' was awarded if the study reported the proportion of males and females and age range and/or mean for participants. A '✗' was given if the study provided only one or no characteristic(s). (c) Adequate assessment of physical self-concept and sub-domains (if used). A '✓' was awarded if authors reported at least one 'acceptable' reliability statistic for all physical self-concept measures (e.g., Cronbach alphas of ≥ 0.70 or test-retest reliability intraclass correlation coefficient; which describes how strongly units in the same group resemble each other, of ≥ 0.70), or uses an established method. A '✗' was given if a single

item measure was used or the study did not report reliability statistics. (d) Adequate assessment of physical activity. A '✓' was awarded if objective measures were used (i.e., heart rate monitors, accelerometers, pedometers, direct observations) or if authors cited adequate validity data for self-report measures in the study population. A '✗' was given for self-report measures when authors did not report validity data. A '✗' was also given if the validity being measured was related to fitness and not physical activity. (e) Appropriate adjustment for covariates (i.e., age and sex) in the statistical analysis (exploring the association between physical activity and physical self-concept). A '✓' was awarded if authors adjusted for age or pubertal status or if authors reported separate findings for boys and girls and different age groups (if students were from the same grade at school this was considered acceptable). A '✗' was given if authors did not adjust for age and sex.

2.8 Description of the synthesis of studies not included in the meta-analysis

A synthesis of studies not included in the meta-analysis was conducted. Of the 47 studies, 29 were cross-sectional, 8 were experimental and 10 were longitudinal. Results were coded using the method employed by Sallis et al.[20] . If 0-33.3% of studies reported a significant association, results were classified as having no association (0). If 34-59% of studies reported a significant association or if fewer than four studies were included, the results were classified as being inconsistent/uncertain (?). If >60% of studies found a significant association, the results were classified as positive (+) or negative (-), depending on the direction of the association. If studies employed multiple analyses, only findings from the highest level of analysis (i.e., multivariate) were considered.

3 Results

The literature search yielded a total of 4666 potentially relevant citations (Figure 1).

Following screening procedures, 332 full text articles were retrieved and reviewed. A total of

111 were considered eligible for the review. A total of 64 studies were included in the meta-analysis consisting of 47 cross-sectional, 12 longitudinal and five experimental studies.

3.1 Study/Sample Characteristics

In terms of country the study was conducted, the USA provided 17 studies, England 12, Australia 7, Canada 5, UK 4, Spain, Finland and Sweden provided 2 each Taiwan, Hong Kong, Mexico, Norway, Germany, Scotland, Cyprus, Poland, Jamaica, Greece, Estonia, Italy and China had a single study included (Electronic Supplementary Material Table S1). A total of 167 independent samples were used in the meta-analysis, which included data from 24,546 girls, 15,215 boys (The sex of 7130 participants was not specified).

3.2 Overall Effect Size, Heterogeneity and Significance of Moderators

3.2.1 General Physical Self-Concept

After correcting for measurement error, the random effects model yielded a weak to moderate effect size of $r = 0.25$ (95% CI= 0.16 to 0.34, $p < 0.001$), suggesting that increased higher physical activity levels were associated with higher levels of general physical self-concept (Electronic Supplementary Material Figure S1). Sex emerged as a statistically significant moderator of effects ($p < 0.05$). Results by sex category were $r = 0.40$ (95% CI= 0.32 to 0.48, $p < 0.001$) for boys (4 studies), $r = 0.26$ (95% CI= 0.16 to 0.36, $p < 0.001$) for girls (15 studies) and $r = 0.20$ (95% CI= -0.01 to 0.39, $p > 0.05$) for the mixed sample (9 studies).

Study design and age were not significant moderators of effects ($p > 0.5$). This is because the association between general physical self-concept and physical activity was not significantly different between sub-groups (e.g., the effect size estimates were similar for cross-sectional, experimental and longitudinal study designs). Results by study design category were $r = 0.25$ (95% CI= 0.13 to 0.36, $p < 0.001$) for cross-sectional designs, $r =$

0.27 (95% CI= 0.11 to 0.42, $p < 0.001$) for longitudinal designs and $r = 0.30$ (95% CI= 0.12 to 0.47, $p < 0.005$) for experimental designs. Results by age category were $r = 0.26$ (95% CI= 0.15 to 0.37, $p < 0.001$) for early adolescence (23 studies) and $r = 0.22$ (95% CI= 0.04 to 0.40, $p < 0.05$) for late adolescence (5 studies).

3.2.2 Perceived Competence

The random effects model correcting for measurement error revealed a moderate effect size of $r = 0.33$ (95% CI= 0.27 to 0.39, $p < 0.001$) (Electronic Supplementary Material Figure S2). Age and emerged as a statistically significant moderator of effects ($p < 0.05$) and a total of 59 samples were extracted. Of these, 1 involved children, 45 were included early adolescents, and 13 studies included late adolescents. Results by age category were $r = 0.08$ (95% CI= -0.12 to 0.28, $p < 0.5$) for children, $r = 0.35$ (95% CI= 0.28 to 0.42, $p < 0.001$) for early adolescents and $r = 0.31$ (95% CI= 0.19 to 0.41, $p < 0.001$) for late adolescents.

Sex and study design were not significant moderators of effects ($p > 0.5$). A total of 59 samples were extracted. Results by sex category were $r = 0.32$ (95% CI= 0.19 to 0.45, $p < 0.001$) for boys, $r = 0.33$ (95% CI= 0.23 to 0.42, $p < 0.001$) for girls and $r = 0.35$ (95% CI= 0.25 to 0.43, $p < 0.001$) for the mixed sample. Results by study design category were $r = 0.32$ (95% CI= 0.24 to 0.39, $p < 0.001$) for cross-sectional designs, $r = 0.34$ (95% CI= 0.24 to 0.43, $p < 0.001$) for longitudinal designs and $r = 0.66$ (95% CI= 0.31 to 0.85, $p < 0.001$) for experimental designs

3.2.3 Perceived Fitness

Higher levels of perceived fitness were moderately associated with increased physical activity in the random effects model $r = 0.30$ (95% CI= 0.23-0.36, $p < 0.001$) (Electronic Supplementary Material Figure S3). Sex, age and study design were not moderators of the association ($p > 0.05$). Results by sex category were $r = 0.40$ (95% CI= 0.32 to 0.48, $p <$

0.001) for boys, $r = 0.30$ (95% CI= 0.23 to 0.37, $p < 0.001$) for girls and $r = 0.25$ (95% CI= 0.02 to 0.45, $p < 0.05$) for the mixed sample. Results by age category were $r = 0.31$ (95% CI= 0.24 to 0.37, $p < 0.001$) for early adolescents and $r = 0.28$ (95% CI= 0.13 to 0.42, $p < 0.001$) for late adolescents. Results by study design category were $r = 0.32$ (95% CI= 0.25 to 0.39, $p < 0.001$) for cross-sectional designs and $r = 0.21$ (95% CI= 0.07 to 0.34, $p < 0.01$) for longitudinal designs.

3.2.4 Perceived Appearance

After correcting for measurement error, the random effects model revealed a weak association between perceived appearance and physical activity, $r = 0.14$ (95% CI= 0.09 to 0.18 $p < 0.001$) (Electronic Supplementary Material Figure S4). Age emerged a statistically significant moderator of effects ($p < 0.01$). A total of 55 samples were extracted and of these, 33 and 22 involved early adolescents and adolescents, respectively. The effect size for early adolescents was $r = 0.19$ (95% CI= 0.13 to 0.24, $p < 0.001$) and for late adolescents was $r = 0.07$ (95% CI= 0.01 to 0.13, $p < 0.05$).

Sex and study design were not significant moderators of effects ($p > 0.5$). Results by sex category were $r = 0.13$ (95% CI= 0.03 to 0.24, ($p < 0.05$) for boys, $r = 0.13$ (95% CI= 0.07 to 0.19, $p < 0.001$) for girls and $r = 0.16$ (95% CI= 0.06 to 0.25, $p < 0.001$) for the mixed sample. Results by study design category were $r = 0.14$ (95% CI= 0.09 to 0.18, $p < 0.001$) for cross-sectional designs, $r = 0.16$ (95% CI= 0.11 to 0.21, $p < 0.001$) for longitudinal designs and $r = 0.13$ (95% CI= -0.09 to 0.33, $p > 0.05$) for experimental designs.

3.3 Synthesis of Findings Not Included in the Meta-analysis

Overall, there were consistent positive associations between physical activity and physical self-concept and its sub-domains. The summary of findings is reported in Table 1.

Table 1: Qualitative summary of studies examining the association between physical activity and physical self-concept.

<u>Measure</u>	<u>Significantly associated with physical activity</u>	<u>Not significantly associated with physical activity</u>	<u>Summary coding</u> <u>n/N^a for benefit</u> <u>%</u>	<u>Association</u>
General physical self-concept	[53-64, 26, 65-73]	[74, 75, 61, 76]	22/26	++
Perceived competence	[77, 74, 54, 78, 55, 56, 79, 57, 58, 61, 62, 80-82, 66, 68, 83, 69, 84, 85, 72, 73, 75, 86]	[75, 61, 64, 87, 73]	24/29	++
Perceived fitness	[77, 53, 56, 57, 88, 61, 80, 81, 68, 83, 87]	[75, 61]	11/13	++
Perceived appearance	[89, 77, 54, 55, 90, 56-59, 91, 88, 61, 63, 80, 81, 92, 66, 83, 69]	[77, 75, 61, 63, 93, 94, 67, 68, 95]	19/28	++

++ = Strong evidence of a positive association.

3.4 Risk of Bias Assessment

Inter-rater reliability metrics for the risk of bias assessments indicated adequate percentage of agreement (94%) for the 320 items (Electronic Supplementary Material Table S3).

Thirteen studies (20%) provided an adequate description of the random sampling process, 59 studies (92%) provided an adequate description of the study sample, 63 studies (98%) provided a valid measure of physical activity, 47 studies (73%) provided a valid measure of physical self-concept and 17 studies (27%) adjusted for covariates.

3.5 Testing for Publication Bias

The classic fail-safe N was high for general physical self-concept (N = 3909), perceived competence (N = 89188), perceived fitness (N = 3450) and perceived appearance (N = 2932). Therefore, a large number of studies with a mean effect of zero would be necessary before the overall effects found in the present study would become not statistically significant. Thus, the significant associations observed in these meta-analyses are likely not the result of publication bias towards significant findings.

In addition, Duval and Tweedie's 'Trim and fill' procedure[43] was used to compute a random-effects estimate of the unbiased effect size. No studies were trimmed for either perceived fitness or perceived appearance; however, two studies were trimmed for general physical self-concept and 18 were trimmed for perceived competence. The general physical self-concept meta-analysis trimmed for extreme values (2 studies) had little impact on the overall estimate, while the trimmed perceived competence meta-analysis (18 studies) resulted in a weaker effect size of $r = 0.22$ (95% CI= 0.15 to 0.29). This finding suggests there is evidence of publication bias that contributed to the observed overall effect size for the association between perceived competence and physical activity.

4 Discussion

4.1 Overview of Findings

The findings from this systematic review and meta-analysis suggest that young people with stronger beliefs about their physical characteristics are more likely to engage in physical activity than those who report lower levels of physical self-concept [96, 97]. However, it is not clear if participation in physical activity leads to improvements in physical self-concept or those with high levels of physical self-concept are attracted to physical activity. Notably, the strength of association between physical activity and physical self-concept (and sub-domains) did not upon depend upon how the data was treated (i.e., whether physical self-concept was the dependent or independent variable) and there is conflicting evidence in the literature regarding associations of this nature. For example, according to the model proposed by Stodden and colleagues (2008), perceived competence is a mediator of the relationship between motor skill competence and physical activity. The model describes two different spirals; one for those who are active with high levels of perceived and actual motor skill competence and another for those who live sedentary lifestyles and possess low levels of competency. As children grow, the divide increases with a positive spiral of engagement leading to higher physical activity levels and a negative spiral of disengagement contributing to physical inactivity.

Alternatively, the EXSEM considers self-efficacy or perceived competence in exercise and sport-related tasks as outcomes of participation. Although there is sufficient evidence from our review and previous studies to conclude that there is a bi-directional association between physical activity and physical self-concept, researchers working in this area are encouraged to conduct mediation analyses to assist in unravelling the nature of the association between physical self-concept and physical activity. Furthermore, separate

analyses that model the bidirectional nature of general physical self-concept and its subdomains as both mediators and moderators of physical activity are needed.

The meta-analysis effect sizes from the current review are similar, but slightly smaller, than those found in previous reviews examining the effects of exercise on self-esteem in young people[98] and adults[99]. While it is plausible to suggest that larger associations would be observed between physical activity and physical self-concept, as compared to global self-esteem which is both more stable and distal from the impact of physical activity[21], both previous reviews were focused on the effects of participation in structured exercise programs. Exercise is planned and repetitive bodily movement done to improve or maintain health-related fitness[100] and according to the EXSEM, individuals who experience improvements in fitness, should also experience changes in global self-esteem (via changes in physical self-perceptions which are more proximal to exercise participation). In contrast, the current review was designed to examine the association between leisure-time physical activity and physical self-concept. Physical activity measures capture a range of organised and non-organised activities and, in the case of objective measures such as accelerometers and pedometers, also collect incidental and lifestyle physical activity (e.g., walking and riding for transportation). Overall, the findings of this systematic review suggest that physical self-concept is important for physical activity in young people and the sub-domains of physical self-concept may play a unique role.

4.2 Summary of Risk of Bias from Included Studies

The findings of this review should be interpreted with some caution as 54 (84%) of the included studies were found to have a high risk of bias. It is a concern that the majority of studies assessed physical activity using a self-report measure. Self-report of physical activity can suffer from reporting bias[70], attributable to a combination of social desirability bias and the cognitive challenges associated with estimating frequency and duration of physical

activity, especially in children[71]. Furthermore, common method artefact may result in stronger correlation coefficients, when two outcomes are measured using the same method of assessment (i.e., self-report) [101]. In addition, few of the studies included participants who were randomly selected from nationally representative populations, which may limit the generalizability of our findings. Only a small percentage of studies adjusted for relevant covariates, which may confound the association between physical self-concept and physical activity. Finally, most of the studies included in this review were cross-sectional and while a number of longitudinal studies were included, such studies do not provide the same level of evidence generated from experimental studies.

4.3 Major Findings and Potential Contributors

This is the first systematic review and meta-analysis of studies examining the association between physical activity and physical self-concept in children and adolescents. The findings suggest that general physical self-concept and its sub-domains (i.e., perceived competence, perceived fitness and perceived appearance) are significantly associated with physical activity in young people. Sex was a significant moderator of the association between physical activity and general physical self-concept, with stronger associations found for boys. Age was also a significant moderator of the association between physical activity and perceived competence and perceived appearance. Notably, study design did not emerge as a significant moderator of the association between physical activity and physical self-concept or any of its sub-domains. Due to the small number of experimental studies, it is not possible to determine if the findings from experimental studies were significantly different to cross-sectional and longitudinal studies.

Perceived competence was found to have the strongest association with physical activity and age emerged as a significant moderator, with the strongest association found in early adolescents. Evidence suggests that young children do not possess the cognitive skills

to accurately assess their motor skill competence. As a result, young children often report inflated levels of perceived competence[54][24, 25], which may explain the weak associations found among children in our review. Stodden and colleagues[23] suggest that perceived motor skill competence will not be strongly correlated to actual levels of motor skill competence nor physical activity during the early childhood years, but by middle childhood they will develop a “sophisticated cognitive capacity to more accurately compare themselves to their peers”. Alternative explanations for the moderating effects of age should be considered as the association between perceived competence and physical activity was slightly weaker in late adolescents. As children progress into adolescence, traditional team sports become less important as young people are exposed to, and participate in more lifelong physical activities (e.g., resistance training, walking, aerobics etc.)[1]. Many lifelong activities are attractive to young people, especially those with low levels of perceived competence, because they do not require competence in fundamental and sports-specific movement skills[102] . As many perceived competence scales include items focused on proficiency in traditional team sports, they may not capture adolescents’ perceptions of their abilities in non-traditional physical activities. Such activities make an increasingly important contribution to adolescents’ leisure-time physical activity[86, 23, 96].

Perceived fitness was found to have the second strongest association with physical activity in children and adolescents. Perceived fitness may be amenable to change and experimental studies have demonstrated that well-designed physical activity or exercise programs can increase perceived fitness in adolescents [31, 32, 58]. However, these studies were not included in the meta-analysis because they did not examine the association between changes in physical activity and changes in physical self-perceptions. Studies often report the association between changes in physical self-concept and actual fitness [58]; however, physical activity and fitness are only weakly related in young people [59, 60]. Research

examining the association between changes in physical self-concept and changes in both fitness and behaviour is warranted. Increasing perceived fitness may have utility as a strategy for increasing physical activity levels in young people, but further testing of this hypothesis in experimental studies is required. Notably, none of the hypothesized moderators were statistically significant.

Perceived appearance was found to have the weakest association with physical activity in the current review. Age was a significant moderator of this association, with the strongest associations found in young adolescents. A recent longitudinal study found that the association between physical activity and perceived body attractiveness weakened over the 12-month study period in a sample of adolescent girls [61]. This finding suggests an increasing divergence between girls' perceptions of their appearance and their involvement in physical activity as they progress through adolescence[62]. Such results may be attributable to bodily changes and increases in body fat that occur with maturation (i.e., through puberty) [62]. Although it is possible that perceived appearance becomes less important to adolescent girls over time, it is likely that this finding reflects an increasing dissatisfaction with their bodies and a disconnect between their actual body shape and their perceived body shape [63-65][103]. For example, a recent nationally representative sample of French adolescents found that one third of adolescents misperceived their body weight and that girls were more likely to overestimate their body weight than boys. This possibility is alarming and provides further support for the importance of enhancing adolescent girls' acceptance of their bodies in attempts to promote physical activity [66, 67].

4.4 Practical Implications

Evidence from this systematic review and meta-analysis suggests that physical self-perceptions (both general and subdomains), are important for physical activity participation in young people. Although it remains unclear if physical self-perceptions are mediators or

outcomes, there is sufficient evidence to suggest that physical activity interventions may benefit from strategies designed specifically to enhance physical self-concept. While it may not be possible to specifically target general physical self-concept, learning experiences and teaching styles that promote a mastery climate may assist in developing both perceived and actual motor skill competence[104-106]. Furthermore, exercise programs that include fitness education, where students learn about the effects of physical activity on fitness and help children link health-related fitness to present and future health status, can improve perceived and actual fitness levels in young people[107, 108]. Fitness testing has an important role to play in this process, but it is important that those administering tests, use appropriate methods that minimize adverse reactions to fitness testing and maximize effort, enjoyment, and motivation in young people[109].

4.5 Strengths and Limitations of the Review

The strengths of this review include the adherence to the PRISMA statement, the large number of studies identified and the inclusion of meta-analyses. Despite these strengths, some limitations should be noted. First, although this review was comprehensive, we did not include studies that were published in languages other than English and we did not include unpublished studies. Second, we did not include studies that examined the association between physical fitness and physical self-concept, as this was considered beyond the scope of the already extensive review. Third, the definition and assessment of physical self-concept and subdomains was not consistent across studies. For example, the global physical self-concept subscale from the Physical Self-Description Questionnaire (PSDQ)[110] includes items that require respondents to evaluate how they feel about themselves in the physical domain (e.g., I feel good about who I am and what I can do physically). For the purpose of our review, we did not exclude studies that described their measure as a physical self-concept scale, but included items that measured physical self-esteem. Additionally, most of

the studies published to date on this topic are cross-sectional or longitudinal; and such studies do not provide the same level of evidence generated from experimental studies.

5 Conclusions

The results of this systematic review and meta-analysis have demonstrated a significant, association between physical activity and physical self-concept in youth. However, due to study heterogeneity and the high risk of bias observed in the included studies, these findings should be interpreted with caution. Although we were unable to establish causality, strategies to increase physical self-concept and sub-domains, particularly perceived physical fitness and competence, may have a role to play in promoting physical activity in young people. In addition, these results highlight the importance of understanding the physical-self and its links to health-related behaviours in youth. Further studies are needed to determine the mechanisms responsible for the effects of physical activity on physical self-concept.

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Figure 1: Results of literature search.

