Moderate-to-Vigorous Physical Activity as a Predictor of Changes in Physical Self-Concept in Adolescents

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Acknowledgements

Preparation of this article was supported in part by a grant from the Australian Research Council (DP130104659).

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This is the prepublication version of the following manuscript:
Garn, A.C., Morin, A.J.S., White, R. L., Owen, K. B., Donley, W., & Lonsdale, C. (in press). Moderate to-vigorous physical activity as a predictor of changes in physical self-concept in adolescents. *Health Psychology*.

Abstract

Objective: Physical self-concept and moderate-to-vigorous physical activity (MVPA) are fundamental components of adolescents' health and well-being. Previous research suggests that physical self-concept and MVPA share reciprocal relations whereby physical self-concept is both an antecedent (i.e., self-enhancement) and outcome (i.e., skill development) of MVPA. However, these studies rely on subjective reports of MVPA, which can produce social desirability bias and challenge youth's recall capabilities. In order to address this gap, we test a reciprocal effects model examining the interplay between adolescents' physical self-concept and its facets and seven days of objectively-measured MVPA. ***Method:*** Australian adolescents (N = 1,767) completed 4,136 time-specific observations across three waves of data. Structural equation modeling was used to test the reciprocal effects model. ***Results:*** After controlling for body mass index and sex, results only supported the role of MVPA as an antecedent of physical self-concept. The percentage of time adolescents spent in MVPA during school was especially important to predicting a higher physical self-concept in the future.

Conclusions: Findings did not support a reciprocal effects model of physical self-concept and objectively-measured MVPA. Rather, physical self-concept and facets were outcomes of school-based MVPA suggesting emphasis be placed on promoting adolescents' physical activity participation. This study demonstrates the benefits that school MVPA provides to adolescents' development of a positive physical self-concept, which is essential to optimizing long-term health and wellbeing.

Keywords: accelerometers, adolescence, physical activity, physical self-concept

Objective Moderate-to-Vigorous Physical Activity Predicts Changes in Adolescents' Physical Self-Concept

A positive self-concept is a key component of mental health and psychological well-being that stimulates adaptive thoughts, emotions, and actions (Craven & Marsh, 2008; Fox & Corbin, 1989; Harter, 2012; Sonstroem, 1978). Positive physical self-concept optimizes well-being because body function is vital to effectively engaging with one's environment. Similarly, consistent participation in physical activity (PA) produces substantial health benefits including improved function of all body systems and reduced risk of morbidity and mortality (World Health Organization, 2010). PA is also associated with enhancements in cognitive and psychological functioning, sleep quality, body image, mental health, and self-conceptions (Bernard et al., 2018; Brand et al., 2017; Kruger, Lee, Ainsworth, & Macera, 2008; Liu, Wu, & Ming, 2015; Stein, Fisher, Berkey, & Colditz, 2007; Vancampfort et al., 2018).

The intersection of physical self-concept and PA is an area of study that epitomizes the interconnection of mind and body (Crocker, Sabiston, Kowalski, McDonough, & Kowalski, 2006; Garn et al., 2016; Lindwall, Asci, & Crocker, 2014; Marsh, Papaioannou, & Theodorakis, 2006; Trautwein, Gerlach, & Ludtke, 2008). According to the World Health Organization Constitution, healthy youth development is fundamental to promoting quality of life and well-being across the lifespan. Indeed, research shows that engaging in recommended levels of PA behaviors during youth increases one's odds of being physically active and healthy as an adult (Telama et al., 2005). During the later stages of youth (i.e., adolescence), awareness of body self-presentation and function (i.e., physical self-concept and its facets) becomes more clearly defined and highly relevant to psychological well-being (Crocker et al., 2006). Furthermore, PA frequency, intensity, and duration generally decline during adolescence (Madsen, McCulloch, & Crawford, 2009; Yli-Piipari, Barkoukis, Jaakkola, & Liukkonen, 2013), while physical self-concept is known to fluctuate as a function of youth biopsychosocial development (Morin et al., 2011; Raustorp & Lindwall, 2015). Taken together, it appears that investigating physical self-concept and PA during adolescence is important because it is a dynamic period of fluctuations and interplay between these two constructs that carries the potential to have lasting impacts on later health trajectories.

The aim of this study was to investigate a reciprocal effects model (REM) of youth physical self-concept and PA (Marsh et al., 2006). In the following section, we describe self-concept and synthesize the rich and informative REM research related to physical self-concept and PA. We address gaps in this literature, with a specific focus on how we designed the present study to address these gaps. Importantly, research to date has generally focused on self-report measures of PA. Therefore, testing the REM of youth physical self-concept and PA using objective measures of PA, such as accelerometers, is warranted.

Physical Self-Concept Reciprocal Effects Model

Physical self-concept is a domain specific aspect of self-concept that refers to the manner in which one defines and evaluates herself/himself physically (Marsh, Martin, & Jackson, 2010; Shavelson, Hubner, & Stanton, 1976). Physical self-concept is generally conceptualized to encompass four specific facets at the subdomain level, including physical attractiveness, physical condition, physical strength, and sport competence (Fox & Corbin, 1989; Lindwall et al., 2014; Maïano et al., 2008). Physical self-concept REMs stem from research testing the skill development and self-enhancement hypotheses (Calysn & Kenny, 1977). The skill development hypothesis states that domain-specific self-concepts are outcomes of domain-specific achievements while the self-enhancement hypothesis maintains that domain-specific self-concepts are antecedents to domain-specific achievements. Support for the REM occurs when evidence substantiates both the skill development and self-enhancement hypotheses simultaneously (Marsh et al., 2006). A critical element to testing REMs is to focus on self-concept domains that match the specific achievement domains considered. Therefore, previous REM studies focusing on PA behaviors have relied on measures of the physical self-concept (Marsh et al., 2006) and its facets (Lindwall et al., 2014). There is consensus that using more global measures lacking specificity in relation to a specific domain or achievement context or measures specific to other domains (e.g., social, academic, or beauty), provides limited value to REM research (Marsh & Cheng, 2012; also see Stein et al., 2007).

Evidence from recent REM studies in the physical domain has yielded mixed results (Crocker et al., 2006; Garn et al., 2016; Lemoyne et al., 2014; Lindwall et al., 2014; Marsh et al., 2006; Trautwein et al., 2008). Both Marsh et al. (2006) and Trautwein et al. (2008) found small positive reciprocal effects between physical self-concept and PA after controlling for numerous demographic factors in large samples of Greek youth and German children, respectively. However, these two studies focused on global physical self-concept, with no facets of the physical self-concept included. In other REM studies, physical self-concept facets appeared to have stronger links to PA when compared to global physical self-concept (Crocker et al., 2006; Garn et al., 2016; Lemoyne et al., 2014; Lindwall et al., 2014). For example, using full information likelihood estimation (FIML) procedures in combination with latent growth and path analysis cross-lagged models Lindwall et al. (2014) found evidence of reciprocal associations between PA and facets of physical self-concept including body attractiveness self-concept, condition self-concept, and strength self-concept, but not global physical self-concept. Babic et al. (2014) revealed a small positive relationship in their systematic review and meta-analysis study on PA and physical self-concept including its facets but noted the direction of the relationship remains unclear.

Almost all of these studies rely on self-report measures of PA (Crocker et al., 2006; Lemoyne et al., 2014; Lindwall et al., 2014; Marsh et al., 2006; Trautwein et al., 2008). Self-reports of PA may suffer from lack of validity, common method variance, social desirability, and recall difficulties, especially in youth (Sirard & Pate, 2001; Taber et al., 2009). Objective measures such as accelerometers capture PA intensity both in and out of school. Although accelerometers do have limitations such as expense, potential measurement variation based on placement, and providing limited information on PA context, they overcome many of the issues of self-report PA measures and represent a best practice in PA measurement (Sirard & Pate, 2001; Taber et al., 2009). There have been correlational studies that demonstrate small, positive relationships between physical self-concept and objective measures of PA such as pedometer steps (Cuddihy, Michaud-Tomson, Jones, & Johnston, 2006) and accelerometer MVPA (Morgan et al., 2003). Baker and Davison (2012) reported positive longitudinal relations between adolescent girls' sport competence and future moderate-to-vigorous PA (MVPA) using accelerometers. However, previous MVPA was not controlled. In one of the few REM studies using an objective measure of PA (accelerometer), Garn et al. (2016) found evidence of relations between physical attractiveness self-concept and PA in a sample of U.S. children (i.e., self-enhancement), but no evidence for reciprocal effects between physical self-concept and PA. However, a major limitation of this study was that only three days of school-based PA were assessed.

The Present Study

The purpose of this study was to investigate a REM of physical self-concept including physical attractiveness, physical condition, physical strength, and sport competence facets and objectively measured MVPA in adolescents. Figure 1 highlights the specific research questions that guided this study. Specifically, our research questions focus on the skill development hypothesis (RQ1), which investigates the extent to which objectively measured MVPA predicts adolescents' future physical self-concept, physical attractiveness self-concept, physical condition self-concept, physical strength self-concept, and sport competence self-concept after controlling for previous levels of these self-concepts. RQ2 focuses on the self-enhancement hypothesis, which examines the extent physical self-concept, physical attractiveness self-concept, physical condition self-concept, physical strength self-concept, and sport competence self-concept predicts adolescents' future objectively measured MVPA after controlling for previous levels of MVPA. Simultaneous support for skill development hypothesis (RQ1) and self-enhancement hypothesis (RQ2) provides evidence for reciprocal effects between a specific physical self-concept dimension and MVPA.

Method

Participants

The sample consisted of 1,767 adolescents (Mage = 12.99, SD = .569, range 11-15), evenly divided across sex (51% girls and 49% boys), attending 14 secondary schools in the Western Sydney area of the State of New South Wales, Australia. Approximately 62% of the sample reported their ethnicity as English Australian while 17% reported Asian, 12% Middle Eastern, 6% South Pacific, and 3% Other. The average height and weight of the participants was 160 cm (SD = 8.06) and 57 kg (SD = 15.41), which translated to an average BMI-for-age of 22 and BMI-for-age z-score of .70. Approximately 25% of the sample could be classified as overweight or obese (Flegal & Cole, 2013).

Procedures

This study was part of a larger project (see Lonsdale et al., 2016; Lonsdale et al., 2019). Permission to conduct the study was approved by the human research ethic committee of Western Sydney University, of the Australian Catholic University, and of the NSW Department of Education. School principals and at least one physical education teacher from each of the fourteen schools authorized the study. Appropriate consent procedures were followed prior to data collection, including parental permission and child assent. Trained research assistants collected the first wave of data in the first term of the 2014 school year when students were in Year 8 (January - April). The second wave of data was collected during the fourth term of Year 8, seven-to-eight months after the first wave (October – December). The third and final wave of data was collected during the second term of Year 9 (April – June), seven-to-eight months after the second wave.

Measures

Physical self-concept. The English version (Morin et al., 2016) of the Physical Self-Inventory – Short Form (PSI-SF) measured participants' global physical self-concept and its facets of physical appearance, physical condition, physical strength, and sport competence (Maïano et al., 2008; Morin & Maïano, 2011; Morin et al., 2018). Sample items are: (a) physical self-concept, "I am proud of what I can do physically"; (b) physical appearance, "I am really pleased with the appearance of my body"; (c) physical condition, "I could run five kilometers without stopping"; (d) physical strength, "I would be good at exercises that require strength"; and (e) sport competence, "I do well in sports". Each subscale consists of three positively worded items, all rated on a six-point Likert Scale ranging from "not at all" (1) to "entirely" (6). The PSI-SF has demonstrated robust psychometric properties in populations similar to this study (Maïano et al., 2008; Morin & Maïano, 2011; Morin et al., 2016, 2018).

Physical activity. Accelerometers (ActiGraph LLC GT1M, GT3X, and GT3X+; Fort Walton Beach, FL) were used to measure participants' MVPA for seven days including five weekdays and two weekend days using one-second epochs. MVPA cutpoints were based on recommendations for youth established by Evenson, Catellier, Gill, Ondrak, and McMurray (2008) of ≥2,296 counts per minute. Non-wear reflected consecutive zero counts for 30 minutes (Carson, Cliff, Janssen, & Okely, 2013). Overall inclusion reflected a minimum of three days of valid data, including at least two weekdays, with a minimum of eight hours per day. Participants' total MVPA counts were the primary behavioral variable; however, we also divided their MVPA into school-time and leisure-time. School-time reflected MVPA occurring during the school day based on the school bell system. Leisure-time reflected MVPA occurring across all waking hours outside of school-time. In order to obtain MVPA measurements that were independent of wear time variations, we created variables based on the percentage of wear time each participant spent in MVPA in total, during the school day, and in their leisure-time.

Body mass index. Participants' height and weight were measured to the nearest tenth of a centimeter and kilogram with a portable stadiometer (Surgical and Medical Products No. 26SM, Medtone Education Supplies, Melbourne, Australia) and digital scale (UC-321, A&D Company LTD, Tokyo, Japan), respectively. Body mass index (BMI) z-scores based on age and sex were calculated, with each participant receiving a weight status classification (Flegal & Cole, 2013). A dummy variable was created to identify overweight and obese participants compared to all other participants.

Data Analysis

A total of 1,767 adolescents completed 4,136 time specific observations (M = 2.341, SD = .788) across the three waves of data. There were 1,525 students at T1, 1,486 at T2, and 1,125 students at T3. Specifically, 54% of the students completed all three waves of data, 26% completed two waves of data, and 20% completed one wave of data. Missing data were handled with FIML procedures (Enders, 2010). FIML is an efficient and effective approach to increasing power and reducing parameter bias in longitudinal research (Graham, 2009; Jeličič, Phelps, & Lerner, 2009; Larsen, 2011). All analyses used the Mplus CLUSTER function to account for the natural nesting of students within classes.

We used preliminary confirmatory factor analyses (CFA) at each of the three time points to test the factor structure of the PSI-S subscales. We calculated composite reliability coefficients (rho) for physical self-concept and its facets based on time specific CFA standardized factor loadings (Raykov, 1997). Next, longitudinal measurement invariance procedures confirmed that self-concept measurement could be considered to be equivalent across time, a necessary element when examining temporal relations at the structural level (Little, 2013). We used a nested measurement invariance approach whereby each subsequent model became more restricted than the previous by adding equality constraints to model parameters (Meredith, 1993). We started with a configural model without equality constraints. A weak invariance model then constrained matching factor loadings to be equal across the three waves of data. Strong invariance added equality constraints on matching indicators' intercepts across time points. Finally, equality constraints were added on the indicators' uniquenesses in a test of strict invariance. Each indicator uniqueness was allowed to covary with itself across the three waves of data in order to avoid converging on inflated stability estimates to a lack of control for repeated wording effects (Marsh, 2007).

We used structural equation modeling (SEM) to investigate RQ1 and RQ2. In these models, physical self-concept and its facets were latent variables defined as in the previous measurement models, while total MVPA, leisure-time MVPA and school MVPA were observed variables. Strict invariance constraints were maintained on the latent factors to ensure comparability of measurement and to maximize statistical power (Little, 2013). We first tested a REM model in which all predictive paths were allowed to vary across both time intervals, and a second REM model with equilibrium (i.e., equivalence) of the reciprocal paths over time. In the second model, equality constraints were placed on beta coefficients across time intervals (T1→ T2 = T2→ T3) to determine the predictive equilibrium of the model (Cole & Maxwell, 2003). Variables were allowed to covary at each time point. Dummy variables reflecting participants' sex and overweight/obesity were also included as covariates for all endogenous variables. We first used this two-step REM process for participants' total MVPA. Next, we reran the REM models using leisure-time MVPA and school MVPA as separate outcomes.

We used a series of goodness-of-fit indicators to assess model fit (Hu & Bentler, 1999; Little, 2013) and to contrast the fit of alternative models (Chen, 2007; Cheung & Rensvold, 2002). Robust chi-square (R-χ^2) tests of exact fit were first reported as a global indicator of model fit. However, because χ^2 values are highly sensitive to sample sizes and to minor misspecifications, we also examined the sample-size independent Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Root Mean Square Error of Approximation (RMSEA) (Marsh, Hau, & Grayson, 2005). Typical interpretation guidelines were followed according to which CFI and TLI values ≥ .90 indicate acceptable fit and ≥ .95 indicate excellent fit, whereas RMSEA values ≤ .08 indicate acceptable fit and ≤ .06 indicate excellent fit (Hu & Bentler, 1999). Hypotheses of measurement invariance and predictive equilibrium were considered to be supported when changes (Δ) in CFI and TLI remained under .01 between a more constrained model and the previous model, and when ΔRMSEA remained under .015 (Chen, 2007; Cheung & Rensvold, 2002).

Results

Table 1 presents the descriptive statistics and composite reliability estimates for each variable at each time point. On average, participants spent approximately 45 minutes per day in MVPA, which remained stable across time. Participants spent 7% to 8% of their time in MVPA, with slight increases across time. Preliminary CFA models resulted in acceptable model fit at all three time points (CFI/TLI > .900; RMSEA < .08; see Table 2). Standardized parameter estimates from these models can be found in Tables S1 (factor loadings and uniquenesses) and S2 (latent correlations between the physical self-concept dimensions, and between the physical self-concept factors and the observed PA indicators) of the online supplements. Model fit statistics related to measurement invariance over time are also reported in Table 2, and support the weak, strong, and strict longitudinal invariance of the physical self-concept measure over time (ΔCFI/TLI < .010; ΔRMSEA < .015).

The bottom section of Table 2 highlights model fit statistics for the REMs. Findings revealed adequate model fit for all four models (CFI/TLI > .900; RMSEA < .08), and supported the predictive equilibrium of the predictive paths (ΔCFI/TLI < .010; ΔRMSEA < .015). Table 3 details the autoregressive, covariates, and reciprocal unstandardized (b) and standardized (β) coefficients estimated from the REM with equilibrium focusing on total MVPA (Little, 2013). These estimates first showed that all constructs demonstrated moderate stability over time, with standardized estimates ranging from .514 (i.e., T1→T2 physical attractiveness self-concept) to .646 (T2→T3 physical condition self-concept).

Estimates of covariates effects revealed that males reported higher levels of physical self-concept across all global and specific subscales except physical condition self-concept when compared to girls. Males, on average, also engaged in more MVPA than females. In addition, adolescents classified as overweight and obese reported lower levels of physical self-concept, physical condition self-concept, sport competence self-concept, and physical attractiveness self-concept compared to the rest of the sample. There were, however, no differences between overweight/obese adolescents and their peers in terms of MVPA and strength self-concept.

In relation to the key predictive paths, findings first provided substantive support to the skill development hypothesis (RQ1). More precisely, MVPA positively predicted higher levels of physical self-concept, physical condition self-concept, sport competence self-concept, and strength self-concept after controlling for previous levels of these facets (see Table 3). However, MVPA showed no longitudinal associations with future levels of physical attractiveness self-concept.

The results failed to support the self-enhancement hypothesis (RQ2). Specifically, neither global physical self-concept nor any facet of the physical self-concept predicted future MVPA. Interestingly, this model was able to explain (R^2) 30% (T2 physical self-concept) to 44% (T3 MVPA) of the variance in study variables (see bottom of Table 3).

Predictive paths and R^2 values of the REM equilibrium model that separately considered school-time and leisure-time MVPA are reported in Table 4. Findings revealed that school-time MVPA played a more prominent role in predicting future levels of physical self-concept and its facets compared to leisure-time MVPA. Specifically, school-time MVPA predicted future levels of physical self-concept, physical condition self-concept, sport competence self-concept and strength self-concept whereas leisure-time MVPA only predicted future levels of sport self-concept. R^2 values were similar to findings from the total MVPA REM.

Discussion

This study investigated a REM of physical self-concept including physical attractiveness, physical condition, physical strength, and sport competence facets and objectively measured MVPA in adolescents. Specifically, we examined the skill development (RQ1) and self-enhancement (RQ2) hypotheses, which reflect key assumptions about mind and body connections. We addressed a major gap in the literature by moving beyond self-report measures of MVPA, instead relying on triaxle accelerometers and measuring seven days of free-living MVPA. Findings provided general support for RQ1 focusing on the skill development hypothesis but failed to support RQ2 highlighting the self-enhancement hypothesis. Thus, our findings suggest that physical self-concept, physical condition self-concept, sport competence self-concept, and strength self-concept were only outcomes of MVPA. By measuring MVPA with accelerometers rather than relying on self-reports this study addressed a major gap in the previous REM research on physical self-concept.

In his early work on physical self-concept, Sonstroem's (1978) theorized that participation in PA was essential to enhancing one's physical self-concept. He was one of the first researchers to apply the skill development hypothesis (Calysn & Kenny, 1977) to the physical domain. In the present study, adolescents' MVPA, mainly during the school day, was found to predict higher levels of global physical self-concept, physical condition self-concept, sport self-concept, and strength self-concept over time. Standardized regression coefficients were small and positive, similar to those observed in previous REM studies using self-report measures of PA (Crocker et al., 2006; Lindwall et al., 2014; Marsh et al., 2006; Trautwein et al., 2008). These similar small positive skill development relations appear across different measurement intervals ranging from six (Marsh et al., 2006) to 15 (Trautwein et al., 2008) months. There is currently less evidence pertaining to REMs over shorter intervals.

This is one of the first REM studies to demonstrate skill development relations between physical self-concept and PA while considering four different facets of the physical self-concept. Previous research by Crocker et al. (2006) and Lindwall et al. (2014) revealed no cross-lagged effects between PA and future global physical self-concept when considering similar facets of youth physical self-concept. Likewise, in a previous study using three days of objectively measured MVPA during school hours, Garn et al. (2016)

found no support for skill development relations involving global physical self-concept or physical attractiveness self-concept. In contrast, our findings suggest that MVPA, at least when assessed over a longer span of days, enhanced multiple facets of the physical self-concept hierarchy (Marsh et al., 2010; Shavelson et al. 1976).

The fact that school MVPA was more prominent than leisure MVPA in promoting skill development effects supports an abundance of research highlighting the important role schools play in promoting adolescents' MVPA (Long et al. 2013). Therefore, it is critical from a health promotion standpoint that schools provide numerous opportunities for adolescents to be physically active. Implementation of daily physical education classes, daily recess breaks, and classroom PA breaks are examples of how adolescents can be more active in schools (Lonsdale et al., 2019). It is especially important to gain support and buy-in from district and school administrators for health promotion strategies because they are rarely used in secondary schools (Lee, Burgeson, Fulton, & Spain, 2006).

There was no support for the self-enhancement hypothesis, contrasting with previous physical self-concept REM findings (Crocker et al., 2006; Garn et al., 2016; Lemoyne et al., 2016; Lindwall et al., 2014; Marsh et al., 2006; Trautwein et al., 2008). It is unclear why our results diverged from these other studies. The use of objectively-measured MVPA eliminated common method variance with physical self-concept and its facets. REM studies that rely on self-report measures of PA are susceptible to common method variance, which may result in biased estimates including covariance inflation (Siemsen, Roth, & Oliveira, 2010). It is also possible that more detail on the PA context, which can be provided in self-report measures but are more difficult with accelerometers, is advantageous for detecting self-enhancement effects. For example, in college students self-enhancement relations were most prominent between matching physical self-concept facets and specific types of PA such as strength self-concept, self-reported weight-training activities as well as physical condition self-concept, and self-reported cardiovascular activities (Lemoyne et al., 2016). Direct observations of PA in future research can provide a rigorous test of the matching physical self-concept facet and PA context refinement of the self-enhancement effects reported by Lemoyne et al. (2016).

Limitations and Future Research

Although sex and weight status were controlled in our REM, we did not control for athletic ability (Trautwein et al., 2008), value of MVPA (Harter, 2012), or pubertal status (Labbrozzi, Robazza, Bertollo, Bucci, & Bortoli, 2013). In terms of athletic ability, it is often difficult to identify standardized tests that reflect diverse types of PA. For example, some tests focus on power and strength (e.g., one-rep maximum lifts), speed (100 meter dash), flexibility (e.g., sit and reach test), or endurance (e.g., progressive aerobic cardiovascular run). The use of numerous tests was not feasible in this study while the use of any single test would provide narrowly focused information on adolescents' ability that would leave many aspects of PA unaccounted for. Similarly, it would also be beneficial for future researchers to determine if adolescents' value toward MVPA moderates the relationship between physical self-concept and MVPA (White et al., 2018). For example, it might be possible that self-enhancement effects occur only when adolescents deem MVPA to be interesting, important, and useful in their daily lives. Nevertheless, future research examining REMs of physical self-concept and objectively measured MVPA should find ways to incorporate athletic ability and value in order to provide comprehensive results on the development of physical self-concept and its facets. Labbrozzi et al. (2013) suggest that advanced pubertal status generally undermines girls' physical self-beliefs and enjoyment toward MVPA. Thus, future REM studies could take this into account.

The aims of this study focused solely on skill development and self-enhancement hypotheses of physical self-concept and MVPA. However, there are diverse statistical methods (Lindwall et al., 2014) and motivational constructs (Marsh et al., 2006) that can enhance physical self-concept REMs. Future research could consider following the lead of Lindwall et al. (2014) and their use of latent growth models to track intra-individual change of physical self-concept and MVPA. In this future work, researchers should collect enough waves of data to examine potential polynomial trajectories of physical self-concept and MVPA. Similarly, this study failed to support the self-enhancement hypothesis, suggesting that crucial mediators, such as PA intentions, PA enjoyment, or self-determined motivation should be explored in future research. Finally, we did not examine these participants' light PA or sedentary behaviors. Future REM studies should investigate the interplay between physical self-concept and lower intensity activities

Conclusion

By measuring seven days of MVPA via accelerometers, this study represents one of the most rigorous tests of the physical self-concept REM to date. Findings were more supportive of the skill development model compared to a self-enhancement model or REM. This reflects some of the original studies on academic self-concept and achievement (Calsyn & Kenny, 1977). Our findings suggest that physical self-concept and its facets function more effectively as outcomes rather than antecedents of MVPA. The motivational properties of physical self-concept toward MVPA may work through proximal mechanisms such as PA intentions. Adding potential psychosocial mediators to physical self-concept REMs may provide a more comprehensive explanation of pathways that connect the mind and body. Finally, this study demonstrates the benefits that MVPA during school hours provides to the development of a positive physical self-concept, which is essential to optimizing long-term health and wellbeing.

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Table 1

Means, Standard Deviations, and Composite Reliability Scores of Study Variables

	Time 1			Time 2			Time 3		
Variable	M	SD	CR	M	SD	CR	M	SD	CR
Physical SC	4.112	1.276	0.846	4.018	1.204	0.847	3.916	1.223	0.855
Attractive SC	3.142	1.331	0.820	3.150	1.311	0.825	3.208	1.326	0.863
Condition SC	3.180	1.276	0.825	3.126	1.299	0.821	3.165	1.300	0.869
Strength SC	3.396	1.219	0.774	3.341	1.189	0.804	3.350	1.193	0.801
Sport SC	3.793	1.257	0.812	3.671	1.242	0.826	3.622	1.232	0.848
Daily MVPA	46.573	19.856	na	47.747	26.482	na	46.539	23.553	na
Total MVPA %	7.292	3.191	na	7.503	3.488	na	7.609	4.016	na
School MVPA %	7.367	3.414	na	7.373	3.740	na	7.882	4.535	na
Leisure MVPA %	7.898	4.945	na	8.369	5.653	na	7.986	6.087	na
BMI	22.218	4.942	na						
BMI z-scores	0.701	1.110	na						

Note. CR = Composite Reliability; Physical SC = physical self-concept; Attractive SC = physical attractiveness self-concept; Condition SC = physical condition self-concept; Strength SC = strength self-concept; Sport SC = sport competence self-concept; MVPA = moderate-to-vigorous physical activity; Daily MVPA = average daily minutes of moderate-to-vigorous physical activity; BMI = body mass index; na = not applicable.

Table 2

Confirmatory Factor Analysis and Structural Equation Model Fit Statistics

Model	$R\chi^2$	df	CFI	TLI	RMSEA	RMSEA 90%CI	$\Delta R\chi^2$ (Δdf)	ΔCFI	ΔRMSEA
Time 1	451.395*	80	0.950	0.935	0.057	0.052; 0.063	na	na	na
Time 2	515.073*	80	0.943	0.926	0.065	0.059; 0.070	na	na	na
Time 3	514.441*	80	0.938	0.919	0.070	0.065; 0.076	na	na	na
Configural	2240.982*	796	0.952	0.940	0.035	0.033; 0.036	na	na	na
Weak	2326.268*	826	0.950	0.940	0.035	0.033; 0.036	84.896 (30)*	0.002	0
Strong	2394.293*	846	0.948	0.939	0.035	0.033; 0.036	63.241 (20)*	0.002	0
Strict	2590.624*	876	0.943	0.935	0.036	0.034; 0.037	264.684 (30)*	0.005	0.001
REM - Total	3335.874	1141	0.929	0.921	0.037	0.035; 0.038	na	na	na
REM - Total Eq	3388.296	1174	0.929	0.923	0.036	0.035; 0.038	77.220 (33)*	0	-0.001
REM - Sch/Lt	3551.900*	1209	0.929	0.919	0.035	0.034; 0.037	na	na	na
REM - Sch/Lt Eq	3597.018*	1250	0.928	0.921	0.035	0.033; 0.036	80.478 (41)*	0.001	0

Note. Eq = equilibrium; REM = reciprocal effects model; CI = confidence interval; Δ = change; na = not applicable. * $p < .01$.

Table 3
Structural Equation Model Results for Total Moderate-to-Vigorous Physical Activity

Predictor	Outcome	b	SE	T1 → T2 β	T2 → T3 β
Autoregressive Paths					
Physical SC	Physical SC	0.614**	0.021	0.515	0.581
Condition SC	Condition SC	0.702**	0.021	0.563	0.646
Sport SC	Sport SC	0.658**	0.022	0.538	0.612
Attractive SC	Attractive SC	0.617**	0.019	0.514	0.583
Strength SC	Strength SC	0.678**	0.020	0.551	0.628
MVPA	MVPA	0.665**	0.032	0.612	0.566
Covariates					
Male	Physical SC	0.138**	0.046	0.057	0.054
Male	Condition SC	0.084	0.046	0.033	0.031
Male	Sport SC	0.163**	0.043	0.066	0.061
Male	Attractive SC	0.181**	0.044	0.075	0.071
Male	Strength SC	0.116*	0.047	0.047	0.041
Male	MVPA	0.064**	0.016	0.093	0.079
Overweigth/Obese	Physical SC	-0.119**	0.038	-0.043	-0.040
Overweigth/Obese	Condition SC	-0.131**	0.043	-0.045	-0.041
Overweigth/Obese	Sport SC	-0.091*	0.043	-0.032	-0.031
Overweigth/Obese	Attractive SC	-0.199**	0.045	-0.071	-0.067
Overweigth/Obese	Strength SC	0.039	0.044	0.014	0.013
Overweigth/Obese	MVPA	0.018	0.019	0.023	0.020
Predictive Paths					
MVPA	Physical SC	0.264**	0.075	0.069	0.071
MVPA	Condition SC	0.335**	0.070	0.084	0.084
MVPA	Sport SC	0.292**	0.065	0.075	0.076
MVPA	Attractive SC	0.094	0.082	0.025	0.025
MVPA	Strength SC	0.260**	0.077	0.067	0.067
Physical SC	MVPA	0.001	0.017	0.001	0.001
Condition SC	MVPA	0.013	0.013	0.037	0.039
Sport SC	MVPA	0.012	0.021	0.037	0.038
Attractive SC	MVPA	-0.014	0.011	-0.041	-0.041
Strength SC	MVPA	0.013	0.014	0.038	0.040
				R^2	**R^2**
	Physical SC			0.297	0.371
	Condition SC			0.358	0.456
	Sport SC			0.330	0.420
	Attractive SC			0.306	0.380
	Strength SC			0.338	0.432
	MVPA			0.443	0.381

Note. Physical SC = physical self-concept; Attractive SC = physical attractiveness self-concept; Condition SC = physical condition self-concept; Strength SC = strength self-concept; Sport SC = sport competence self-concept; MVPA = moderate-to-vigorous physical activity. * p < .05, ** p < .01.

Table 4

Structural Equation Model Results for School and Leisure-Time Moderate-to-Vigorous Physical Activity

				T1 → T2	**T2 → T3**
Predictor	**Outcome**	**b**	**SE**	**β**	**β**
Leisure MVPA	Physical SC	0.006	0.004	0.026	0.029
School MVPA	Physical SC	0.016**	0.006	0.045	0.048
Leisure MVPA	Condition SC	0.009	0.005	0.035	0.038
School MVPA	Condition SC	0.016**	0.006	0.043	0.045
Leisure MVPA	Sport SC	0.008*	0.004	0.034	0.036
School MVPA	Sport SC	0.015**	0.006	0.040	0.042
Leisure MVPA	Attractive SC	0.001	0.005	0.005	0.006
School MVPA	Attractive SC	0.004	0.007	0.011	0.011
Leisure MVPA	Strength SC	0.007	0.004	0.029	0.031
School MVPA	Strength SC	0.016*	0.007	0.043	0.045
Physical SC	Leisure MVPA	-0.237	0.293	-0.042	-0.046
Physical SC	School MVPA	0.009	0.230	0.003	0.002
Condition SC	Leisure MVPA	0.387	0.295	0.068	0.079
Condition SC	School MVPA	0.017	0.198	0.005	0.005
Sport SC	Leisure MVPA	0.424	0.354	0.075	0.085
Sport SC	School MVPA	0.079	0.260	0.021	0.021
Attractive SC	Leisure MVPA	-0.346	0.212	-0.061	-0.068
Attractive SC	School MVPA	0.068	0.138	0.018	0.018
Strength SC	Leisure MVPA	0.014	0.196	0.002	0.003
Strength SC	School MVPA	0.111	0.198	0.030	0.030
				R^2	**R^2**
	Physical SC			0.294	0.369
	Condition SC			0.354	0.453
	Sport SC			0.327	0.415
	Attractive SC			0.308	0.383
	Strength SC			0.334	0.427
	MVPA			0.242	0.277
	School MVPA			0.357	0.303

Note. Physical SC = physical self-concept; Attractive SC = physical attractiveness self-concept; Condition SC = physical condition self-concept; Strength SC = strength self-concept; Sport SC = sport competence self-concept; MVPA = moderate-to-vigorous physical activity. * p < .05, ** p < .01.

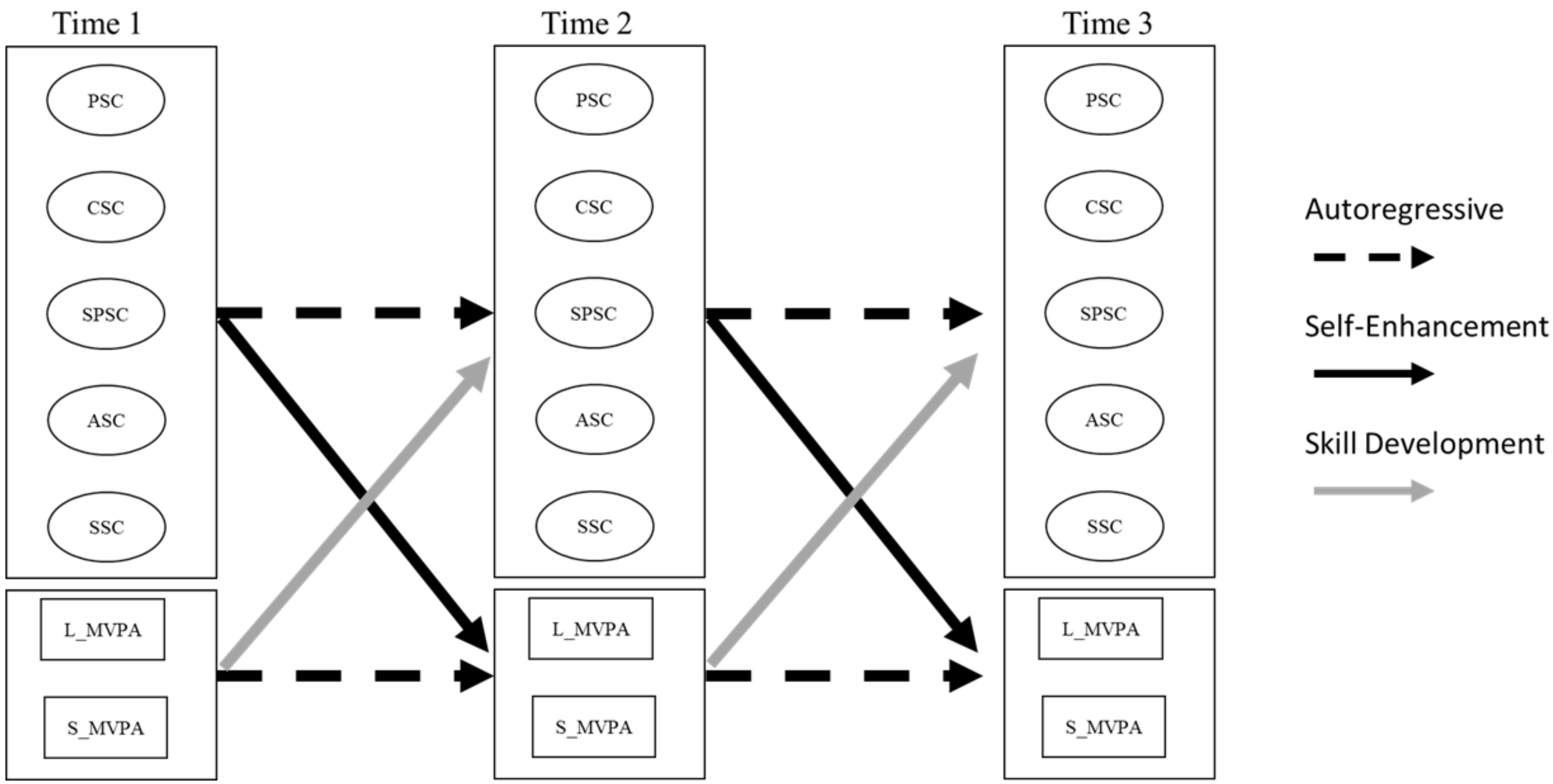

Figure 1. Reciprocal effects model of physical self-concept (PSC), physical condition self-concept (CSC), sport competence self-concept (SPSC), physical attractiveness self-concept (ASC), strength self-concept (SSC), objectively measured leisure moderate-to-vigorous physical activity (L_MVPA) and school moderate-to-vigorous physical activity (S_MVPA).

Online Supplements for:

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We developed these materials to provide additional technical information and to keep the main manuscript from becoming needlessly long. We would, however, be happy to have some of these materials brought back into the main manuscript, or included as published appendices if the editor deems it useful.

Table S1
Confirmatory Factor Analysis Standardized Factor Loadings (λ) and Uniquenesses (δ) Results

	Time 1		Time 2		Time 3		Invariance	
Indicator	λ	δ	λ	δ	λ	δ	λ	δ
PSC_1	0.808	0.348	0.810	0.344	0.829	0.312	0.817	0.332
PSC_2	0.809	0.540	0.808	0.449	0.794	0.392	0.808	0.470
PSC_3	0.797	0.345	0.797	0.347	0.818	0.369	0.801	0.348
CSC_1	0.778	0.394	0.836	0.302	0.824	0.321	0.807	0.349
CSC_2	0.770	0.288	0.793	0.314	0.842	0.269	0.795	0.295
CSC_3	0.634	0.272	0.700	0.293	0.727	0.247	0.703	0.271
SPSC_1	0.844	0.281	0.828	0.276	0.855	0.232	0.840	0.265
SPSC_2	0.627	0.364	0.653	0.365	0.697	0.330	0.653	0.359
SPSC_3	0.824	0.408	0.857	0.371	0.859	0.292	0.847	0.369
ASC_1	0.853	0.607	0.841	0.574	0.868	0.515	0.854	0.574
ASC_2	0.807	0.570	0.787	0.537	0.851	0.498	0.813	0.537
ASC_3	0.661	0.598	0.714	0.510	0.744	0.472	0.706	0.505
SSC_1	0.679	0.321	0.742	0.266	0.780	0.263	0.728	0.283
SSC_2	0.848	0.349	0.851	0.380	0.876	0.276	0.857	0.339
SSC_3	0.656	0.564	0.680	0.491	0.709	0.447	0.681	0.501

Note. All coefficients are statistically significant ($p < .01$).

Table S2

Correlation Matrix of Study Variables at Time 1, Time 2, and Time 3

	T1PSC	T1CSC	T1SPSC	T1ASC	T1SSC	T1LMVPA	T1SMVPA	T2PSC	T2CSC	T2SPSC	T2ASC	T2SSC	T2LMVPA	T2SMVPA	T3PSC	T3CSC	T3SPSC	T3ASC	T3SSC	T3LMVPA	T3SMVPA
T1PSC																					
T1CSC	0.771																				
T1SPSC	0.835	0.837																			
T1ASC	0.672	0.704	0.649																		
T1SSC	0.738	0.755	0.809	0.622																	
T1LMVPA	0.107	0.132	0.135	0.113	0.142																
T1SMVPA	0.163	0.206	0.219	0.169	0.159	0.332															
T2PSC	0.638	0.542	0.621	0.514	0.509	0.190	0.190														
T2CSC	0.547	0.740	0.602	0.512	0.521	0.156	0.248	0.765													
T2SPSC	0.590	0.598	0.704	0.475	0.562	0.157	0.239	0.853	0.818												
T2ASC	0.508	0.511	0.457	0.681	0.421	0.085	0.169	0.718	0.667	0.645											
T2SSC	0.500	0.506	0.574	0.445	0.711	0.172	0.209	0.724	0.738	0.791	0.622										
T2LMVPA	0.151	0.152	0.183	0.114	0.180	0.472	0.261	0.116	0.109	0.163	0.073	0.160									
T2SMVPA	0.174	0.204	0.205	0.157	0.166	0.322	0.610	0.219	0.272	0.267	0.229	0.250	0.322								
T3PSC	0.596	0.550	0.536	0.470	0.475	0.203	0.203	0.672	0.765	0.853	0.528	0.485	0.008	0.183							
T3CSC	0.537	0.683	0.527	0.496	0.439	0.134	0.134	0.765	0.722	0.563	0.501	0.488	0.127	0.214	0.764						
T3SPSC	0.565	0.624	0.698	0.478	0.544	0.131	0.235	0.617	0.598	0.698	0.491	0.573	0.176	0.215	0.860	0.827					
T3ASC	0.434	0.507	0.400	0.598	0.386	0.077	0.168	0.527	0.489	0.432	0.598	0.435	0.091	0.168	0.762	0.730	0.687				
T3SSC	0.472	0.499	0.530	0.434	0.639	0.150	0.180	0.551	0.531	0.602	0.458	0.728	0.150	0.194	0.730	0.730	0.820	0.655			
T3LMVPA	*0.058*	*0.080*	*0.053*	*0.057*	0.077	0.393	0.214	*0.030*	0.122	*0.053*	*-0.008*	0.083	0.514	0.243	*0.030*	0.077	0.160	*0.001*	0.072		
T3SMVPA	0.195	0.209	0.220	0.230	0.194	0.298	0.596	0.219	0.269	0.220	0.237	0.261	0.298	0.596	0.198	0.216	0.223	0.184	0.199	0.290	

Note. All coefficients are statistically significant ($p < .05$) except for estimates in italics. Physical self-concept (PSC), physical condition self-concept (CSC), sport competence self-concept (SPSC), physical attractiveness self-concept (ASC), strength self-concept (SSC) are latent variable. Objectively measured leisure moderate-to-vigorous physical activity (L_MVPA) and school moderate-to-vigorous physical activity (S_MVPA) are observed variable.