
Description and evaluation of a social cognitive model of physical activity behaviour tailored for adolescent girls

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Abstract

The aim of this paper was to describe and test a social cognitive model of physical activity tailored for adolescent girls. Participants were 1518 girls (aged 13.6 ± 0.02 years) from 24 secondary schools in New South Wales, Australia. Useable accelerometer (≥ 10 hours day⁻¹ on at least 3 days) and questionnaire data were obtained from 68% of this sample ($N = 1035$). Participants completed questionnaires assessing psychological, behavioural, social and environmental correlates of activity. The theoretical model was tested using structural equation modelling in AMOS. The model explaining accelerometer counts per minute was an adequate-to-good fit to the data (Tucker–Lewis Index = 0.89, the comparative fit index = 0.97 and the root mean square of approximation = 0.098; 90% confidence interval = 0.075–0.122) but explained only 5% of the variance in activity. There were significant model pathways from self-efficacy ($r = 0.11$, $P = 0.01$), school environment ($r = 0.07$, $P = 0.02$) and physical self-worth ($r = 0.07$, $P = 0.04$) to accelerometer counts. Although the proposed model provided an adequate-to-good fit to the data, it explained a small portion of the variance. Shared method variance may explain the larger portions of variance explained in previous studies. Future

studies are encouraged to evaluate theories of physical activity behaviour change using objective measures of physical activity.

Introduction

Numerous theories of health behaviour have been developed, applied and evaluated in an attempt to explain physical activity behaviour. Bandura's Social Cognitive Theory (SCT) [1, 2], the Theory of Planned Behaviour [3] and the Transtheoretical Model (TTM) [4] are some of the most commonly tested models that have been applied to physical activity behaviour. More recently, socioecological models that highlight the importance of the broader social, cultural and environmental context have been recommended [5]. Despite extensive progression in the field of physical activity theory, including the integration of existing theories, the majority of the variance in physical activity remains unexplained. One possible explanation for the failure of existing models to adequately explain physical activity is that few studies have proposed models for specific subpopulations. Although the majority of existing models have been designed for adult populations, one notable exception is the Youth Physical Activity Promotion model [6], which was developed to explain the physical activity behaviour of children and adolescents. However, motivations to be active and participation itself

evolve over time and will be different for children (ages 4–12 years), adolescents (ages 13–18 years) and adults [7]. The inclusion of children and adolescents in the one model fails to account for the social, cognitive and biological changes and characteristics unique to childhood and adolescence [8].

It has been suggested that youth physical activity interventions should be tailored for specific at-risk groups [9]. Adolescent girls are one such group. Girls are less active than boys at all ages [10] and the physical activity decline during adolescence is steeper among adolescent girls [11]. Interventions targeting adolescent girls should be guided by a relevant theory of behaviour change. Currently, no such specialist theory exists. In this paper, we describe and evaluate a social cognitive model of physical activity for adolescent girls (Fig. 1). The proposed model is based on Bandura’s SCT [2] but has been tailored to adolescent girls using the available evidence (i.e. reviews of physical activity interventions, correlates and mediators) and includes the following constructs: physical activity self-efficacy, outcome expectations, barriers and facilitators, behavioural strategies and physical self-concept.

In SCT, self-efficacy is considered to be a central determinant because it affects health behaviour both directly and indirectly through its influence on other determinants [2]. Similarly, in the proposed model, self-efficacy is hypothesized to have both direct and indirect effects on physical activity behaviour. Self-efficacy is one of the most consistent correlates of physical activity for adolescent girls [10, 12] and has been identified as an important mediator of physical activity behaviour in interventions among adolescents [13]. The expected benefits and costs of performing a behaviour, known as outcome expectations [1], are also included in the model. Although important for adults, the long-term benefits of physical activity are less important motivators for adolescents to be active [7]. Conversely, enjoyment, spending time with friends and maintaining a healthy weight have been linked to motivation for physical activity among adolescent girls [10,14–16]. As proposed by Bandura [2], self-efficacy beliefs shape individuals’ expectations about the outcomes of activity. While individuals with high self-efficacy are more likely to enjoy activity and have more positive expectations about participation, those with low

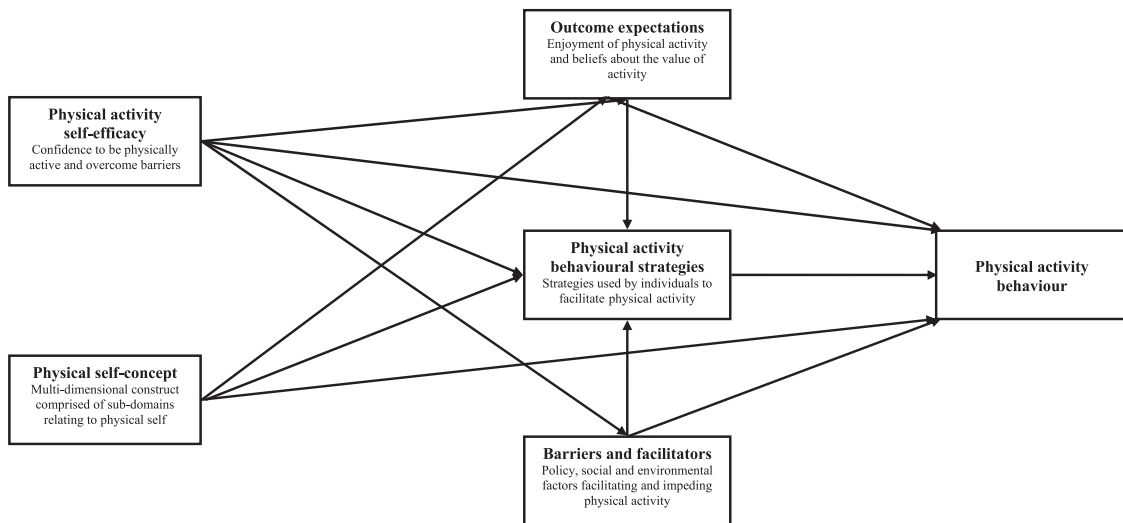


Fig. 1. Hypothesized model of activity for adolescent girls. Note: model based on Bandura’s SCT.

self-efficacy are less likely to enjoy it and may be easily convinced of the futility of their actions.

The proposed model incorporates barriers and facilitators which are hypothesized to have both direct and indirect effects on physical activity. Barriers and facilitators include interpersonal and intrapersonal factors (e.g. social support), environmental and community factors (e.g. available facilities) and relevant policy factors (e.g. school policies relating to physical activity). Socioecological models assert that behaviour is partially influenced by institutional factors, community factors and public policy [17]. Although attempts to explain activity among youth have typically focused on psychosocial determinants of behaviour, studies demonstrating the importance of the physical environment on physical activity among youth have recently emerged in the literature [18].

Although physical education (PE) is not included as an independent construct in our conceptual model, we recognize that PE classes contribute to physical activity participation among adolescent girls. Firstly, PE has a direct effect on youth activity by providing adolescents with an opportunity to participate in physical activity. However, the activity levels of students observed in PE lessons are generally low and the contribution of PE to overall activity is quite small [19]. Secondly, PE classes provide an environment for students to develop movement and behavioural skills [20], both of which are linked to participation in physical activity among adolescents [21, 22]. Finally, PE is hypothesized to have an indirect effect on youth activity as students' experiences in PE will influence their behaviour through the development of values, beliefs and attitudes [2]. Negative attitudes towards PE may negatively influence future participation in physical activities outside of school [23].

Physical activity behavioural skills, such as goal setting, self-monitoring and positive self-talk, are important components of SCT [2]. Behavioural strategies are the tactics used by individuals to increase their activity levels and ensure that physical activity is enjoyable and rewarding. While beliefs about overcoming barriers are thought to predict exercise adoption, beliefs about behaviour self-regulation

may predict long-term exercise adherence [24, 25]. In adults, there is strong empirical support for behavioural skills as mediators of physical activity behaviour change [26]. Fewer studies have explored the importance of behavioural strategies in adolescent populations [13]; however, there is evidence from intervention studies [25, 27] that physical activity behavioural strategies are also important for adolescents. The use of behavioural strategies may help individuals overcome the barriers to physical activity and represent an important opportunity for intervention as they can be learnt and reinforced in well-designed interventions.

The final component of the model is physical self-worth. While self-concept is generally viewed as one's awareness of personal attributes and limitations in comparison with others, self-worth or self-esteem is the evaluative component of self-concept and refers to the value that individuals place on their personal characteristics [28]. Physical self-concept is thought to be a multidimensional construct comprised the following components: perceived strength, body fat, endurance/fitness, sport competence, coordination, health, appearance and flexibility [29]. The degree to which these sub-domains might influence an adolescent's physical self-worth is dependent on the value placed on each sub-domain, which is likely to differ by gender [30]. While muscularity and physical strength have been identified as contributors to global self-esteem in adolescent boys [31], body image and physical appearance are factors influencing physical activity decision making among adolescent girls [32]. The inter-relationships between physical self-concept and self-worth cognitions and behaviour are complicated. Previous studies have identified physical self-worth to be a predictor of physical activity [33] and an outcome of exercise [34] in adolescent girls. In the proposed model, physical self-worth represents how the adolescent girls feel about themselves in the physical domain.

The majority of studies that have tested theories of physical activity behaviour have used self-report measures of activity. However, young people have difficulty in recalling information about their activity patterns [35] and social desirability bias may

lead to over-reporting [36, 37]. Recent studies have evaluated the associations between selected constructs from SCT and objectively measured physical activity in adolescent girls [38, 39]. To the authors' knowledge, no previous study has tested a tailored version of Bandura's SCT using accelerometers in a large sample of adolescent girls. Therefore, the aim of this paper was to describe and test a social cognitive model of physical activity tailored for adolescent girls.

Methods

Participants

The sample comprised 1518 adolescent girls [mean age (SD) = 13.5 (0.4) years] from 24 secondary schools which were selected to take part in a 2-year group-randomized trial, known as the Girls in Sport (GIS) Action Research Project. GIS is part of a state-wide initiative called the Premier's Sporting Challenge, which is focused on the promotion of physical activity in children and adolescents in government schools in the state of New South Wales, Australia. The GIS intervention was an 18-month school-based program targeting girls in Grades 8 and 9 (middle school) through school sport, school ethos and links with the local community. Ethics approval for the study was provided by the New South Wales (NSW) Department of Education and Training and relevant university ethics committees. Thirty-two secondary schools from four diverse geographical regions in New South Wales tendered an Expression of Interest for the study to the NSW Department of Education and Training and were assessed for eligibility. The four regions, outer Sydney metropolitan, Illawarra and South Coast, Hunter and New England and the North Coast, included a range of socio-economic, urban and rural settings. From the original 32 schools, 8 were considered ineligible for study based on the a priori criteria, leaving 24 that were matched and then randomly allocated to the intervention or control group. To be eligible for the study, the participants at the study schools needed to be enrolled in Grade

8 (second year of secondary school in NSW) within the participating schools and had written parental consent. Approximately 85% of Grade 8 girls from all study schools consented to participate in the study. Data were collected within individual school settings.

Measures

Data collection

The accelerometers and questionnaires were administered by a team of measurement staff. This team consisted of trained research assistants (RAs), who were trained by the chief investigators and supervised by the Project Manager and Department of Education and Training staff. Due to the large number of students involved in the study, baseline data were collected from February 2009 to June 2009 (School Terms 1 and 2). The questionnaires used to assess social-cognitive constructs were administered using paper and pencils in a secluded area on two separate days (i.e. when the accelerometers were distributed and then when they were collected) to reduce participant burden. The data collectors checked for incorrectly completed questionnaires (i.e. pages or items not filled in) and asked girls to complete any missing responses.

Physical activity

To provide an objective measure of physical activity, Actigraph accelerometers (MTI model 7164 and GT1M) were used. The participants were required to wear the accelerometers during waking hours for seven consecutive days, except while bathing and swimming. The accelerometers were worn on the girls' right hips and attached with a small elastic belt by trained RAs. Data were collected and stored at 30-s epochs. Trost *et al.* [40] have reported that ActiGraph counts correlated highly ($r = 0.87$) with energy expenditure estimated by indirect calorimetry among children. To enhance the quality of the accelerometer data across the range of collection sites, all RAs were formally trained in standardized accelerometer protocols as recommended by Trost *et al.* [41]. Text messages were sent using an automated online service approximately

mid-way through the 7-day monitoring period and then on the day before the accelerometers were due to be returned to the data collection team. This process prompted return of the equipment and anecdotally enhanced compliance. Only the participants who wore the accelerometer for ≥ 600 min day⁻¹ and for at least 3 days were included in the study on ≥ 3 days [42, 43]. The mean activity counts per minute (CPM) of monitoring time was determined and used in the analyses as a measure of total physical activity. Thirty-second activity counts were uploaded to establish the amount of time spent in light (light physical activity; 1.5–2.9 moderate physical activity (METs)) moderate (MPA; 4–6.9 METs) and vigorous (vigorous physical activity; ≥ 7 METs) activity during the monitoring period. Age-specific count ranges relating to the intensity levels described above were based on prediction equations for energy expenditure [44].

Self-report variables

Two questionnaires were used to assess the psychological (i.e. physical activity self-efficacy, enjoyment of physical activity and physical self-concept), behavioural (i.e. physical activity behavioural strategies), social (i.e. social support for physical activity from peers) and environmental (i.e. perceived physical environment) correlates of physical activity. Scale descriptions and sources, example items, internal consistency, 1-week test–retest reliability and scale validities are reported in Table I. The questionnaires included previously developed scales [45–49] and one scale (perceived physical environment) developed specifically for this study.

Data analysis

Means, standard deviations (SDs), bivariate correlations and regression coefficients were calculated using PASW Statistics 17 (SPSS Inc., Chicago, IL, USA) software. The physical activity data were skewed and normality was improved using the square root function. Structural equation models (SEMs) were examined using AMOS 17.0 (Small Waters Corp., Chicago, IL, USA). Means of completed items were imputed for missing items in

scales (<1% of items missing) and cases were removed from the analysis if girls did not answer $\geq 75\%$ of the scale items. Univariate outliers were retracted to ± 3.29 SDs from the mean for the physical activity data [50].

To correct for the clustering of effects at the school level, each variable was adjusted for school using multiple linear regression, and the unstandardized residuals were used in all analyses [51]. The variables (e.g. physical activity, self-efficacy) were regressed onto the school variable and the unstandardized residuals were used in the analyses. A two-stage process was used to test the proposed model of physical activity. The first stage involved the use of AMOS to develop one-factor congeneric measurement models to supply proportionally weighted composites from multiple indicators of latent constructs. In the second stage, the developed constructs were used to test the proposed model using maximum likelihood analysis in AMOS. CPM was the dependent variable in the SEMs and the mean number of minutes spent in moderate-to-vigorous physical activity (MVPA) was also tested in the models.

Model fit was assessed using multiple indices, including two incremental fit indexes—the comparative fit index (CFI) and the Tucker–Lewis Index (TLI)—and one absolute fit index—the root mean square of approximation (RMSEA). CFI and TLI scores >0.90 and RMSEA values <0.08 have traditionally been used to indicate good model fit [52]. While more recently Hu and Bentler [53] have proposed alternative model fit values (CFI and TLI, >0.95 ; RMSEA, <0.06), others have argued against using these higher cut-off criteria [54]. Using the strategy adopted by Lonsdale *et al.* [55], we have employed the traditional criteria to indicate good model fit and Hu and Bentler's [53] criteria as evidence of very good fit.

Results

Descriptives

Useable accelerometer data (≥ 10 hours per day on at least 3 days) were obtained from 79% of this sample

Table I. *Self-reported variables assessed*

Variables	Description	Range (Number of items)	Source	ICC (95% Confidence interval)	α	CFI	TLI	RMSEA	Loadings
Physical activity self-efficacy	Participants were asked to rate their confidence to be physically active in a variety of adverse situations. Example item: 'I can be physically active during my free time on most days even if it is hot or cold outside'. Scale: 1 = disagree a lot to 5 = agree a lot	1–5 (8)	Motl <i>et al.</i> [45]	0.90 (0.85–0.94)	0.78	0.98	0.98	0.040	0.42–0.74
Enjoyment of physical activity	Participants were asked to respond to a number of statements about the effects of physical activity starting with the common stem; 'When I am active ...' Example item: 'I feel bored'. Scale: 1 = strongly disagree to 5 = strongly agree	1–5 (7)	Motl <i>et al.</i> [46]	0.86 (0.77–0.91)	0.90	0.97	0.96	0.089	0.62–0.82
Social support for physical activity	Participants were asked to indicate how often they were active with their friends and how often they received and provided social support for physical activity. All items started with common stem: 'During a typical week, how often?' Example item: 'Do your friends encourage you to do physical activities or play sports?' Scale: 1 = never to 5 = daily	1–5 (4)	Sallis <i>et al.</i> [47]	0.82 (0.72–0.89)	0.75	0.99	0.98	.068	0.67–0.75
Physical activity behavioural strategies	Participants were asked to indicate how often they used a variety of behavioural and cognitive strategies to increase their physical activity. Example item: 'I try to think more about the benefits of physical activity and I say positive things to myself about physical activity'. Scale: 1 = never to 5 = very often	1–5 (7)	Saelens <i>et al.</i> [48]	0.93 (0.89–0.96)	0.85	0.92	0.87	0.123	0.58–0.72
School physical activity environment	Participants were asked to rate the quality, accessibility and availability of the physical activity facilities at their school. Example item: 'The physical activity facilities at my school are easily accessible to me'. Scale: 1 = strongly disagree to 5 = strongly agree	1–5 (7)	Developed for current study	0.69 (0.51–0.81)	0.80	0.96	0.94	0.072	0.52–0.67

Table I. *Continued*

Variables	Description	Range (Number of items)	Source	ICC (95% Confidence interval)	α	CFI	TLI	RMSEA	Loadings
Physical self-worth	The scale uses a four-choice structured alternative format. Participants must first decide which of the two statements best describes them and then choose whether the statement is 'Sort of true' or 'Really true' for them. Example item: 'Some people feel extremely proud of who they are and what they can do physically'. Scale 1 = low self-perception to 4 = high self-perception	1–4 (6)	Fox and Corbin [49]	0.93 (0.89–0.95)	0.84	0.99	0.98	0.061	0.62–0.77
Perceived sport competence	Example item: 'Some people feel that they are not very good when it comes to playing sports'. Scale 1 = low self-perception to 4 = high self-perception	1–4 (6)	Fox and Corbin [49]	0.84 (0.75–0.90)	0.80	0.96	0.94	0.088	0.60–0.75
Perceived physical condition	Example item: 'Some people are not very confident about their level of physical conditioning and fitness'. Scale 1 = low self-perception to 4 = high self-perception	1–4 (6)	Fox and Corbin [49]	0.92 (0.88–0.95)	0.84	0.96	0.94	0.096	0.63–0.76
Perceived body attractiveness	Example item: 'Some people feel that compared with most, they have an attractive body'. Scale 1 = low-self-perception to 4 = high self-perception	1–4 (6)	Fox and Corbin [49]	0.91 (0.85–0.94)	0.84	0.98	0.97	0.065	0.67–0.79
Perceived physical strength	Example item: 'Some people feel that they are physically stronger than most people of their sex'. Scale 1 = low self-perception to 4 = high self-perception	1–4 (6)	Fox and Corbin [49]	0.90 (0.84–0.94)	0.80	0.95	0.92	0.101	0.58–0.74

ICC, intra class correlation for 1-week test–retest reliability conducted; α , Cronbach alpha from the study sample; Loadings = range of item loadings.

Table II. Descriptive statistics and bivariate correlations among study variables

Variable	Descriptives ^a														
	N	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12
1. CPM	1164	424	130	—											
2. MVPA (mins)	1164	38.1	17.0	0.89***	—										
3. Self-efficacy	1164	3.7	0.6	0.20***	0.21***	—									
4. Enjoyment	1164	4.3	0.6	0.14***	0.17***	0.56***	—								
5. Social support	1164	3.1	0.7	0.16***	0.18***	0.51***	0.39***	—							
6. School environment	1164	3.7	0.6	0.15***	0.14***	0.38***	0.28***	0.29***	—						
7. Behavioural strategies	1164	3.6	0.7	0.15***	0.18***	0.60***	0.55***	0.52***	0.31***	—					
8. Physical self-worth	1164	2.7	0.7	0.16***	0.17***	0.43***	0.41***	0.33***	0.20***	0.38***	—				
9. Sport competence	1164	2.6	0.6	0.19***	0.20***	0.48***	0.48***	0.34***	0.19***	0.42***	0.71***	—			
10. Physical condition	1164	2.7	0.6	0.20***	0.21***	0.53***	0.48***	0.39***	0.22***	0.46***	0.77***	0.74***	—		
11. Body attractiveness	1164	2.4	0.7	0.11**	0.12***	0.28***	0.23***	0.21***	0.11***	0.22***	0.67***	0.47***	0.56***	—	
12. Physical strength	1164	2.5	0.6	0.15***	0.15***	0.35***	0.31***	0.24***	0.14***	0.33***	0.58***	0.62***	0.57***	0.37***	—

^aUnadjusted means and SDs reported. ** $P < 0.01$, *** $P < 0.01$.

($N = 1200$). Univariate and multivariate skewness and kurtosis values were examined in PASW and AMOS, respectively. The univariate distribution of data were normal; however, the multivariate kurtosis value represented by Mardia’s coefficient was $z = 13.68$ and $z = 13.452$ for CPM and MVPA minutes, respectively. As the recommended value is <3 [56], the Bollen–Stine bootstrap procedure was used to test model fit and bias-corrected regression coefficients are reported. Descriptive statistics and bivariate correlations are reported in Table II. Model fit indices for each of the scales are reported in Table I. All the scales demonstrated good internal consistency and test–retest reliability and adequate-to-good fit to the data, based on RMSEA and CFI indices.

Model fit (CPM)

The proposed model (Fig. 2) explained 5% of the variance in CPM. While the Bollen–Stine P -value was significant ($P < 0.001$), the fit indices suggested that the model was an adequate-to-good fit to the data (TLI = 0.89, CFI = 0.97 and RMSEA = 0.098, 90% confidence interval = 0.075–0.122). There were significant model pathways from self-efficacy ($\beta = 0.11$, $P = 0.01$), school environment ($\beta = 0.07$, $P = 0.02$) and physical self-worth ($\beta = 0.07$, $P = 0.04$) to accelerometer counts. In addition, there were significant pathways from self-efficacy to enjoyment ($\beta = 0.46$, $P = 0.001$), social support ($\beta = 0.51$, $P = 0.001$),

school environment ($\beta = 0.38$, $P = 0.001$) and behavioural strategies ($\beta = 0.29$, $P = 0.001$).

Model fit (MVPA minutes)

The model explained 6% of the variance in accelerometer MVPA minutes and model fit indices were identical for the model predicting MVPA (% time) (Fig. 3). The pathways from self-efficacy ($\beta = 0.09$, $P = 0.02$) and physical self-worth ($\beta = 0.07$, $P = 0.03$) to MVPA minutes were statistically significant.

Discussion

The primary aim of this study was to describe and evaluate a model of physical activity behaviour for adolescent girls using an objective measure. Although the proposed model provided an adequate-to-good fit to the data, only 5% of the variance in physical activity was explained. There were significant model pathways from self-efficacy, school environment and physical self-worth to accelerometer counts, reinforcing the importance of these constructs in explaining adolescents girls’ physical activity behaviours.

Few studies have tested models of youth physical activity using objectives measures. Compared with previous studies that have used self-report measures, the current study explained only a small

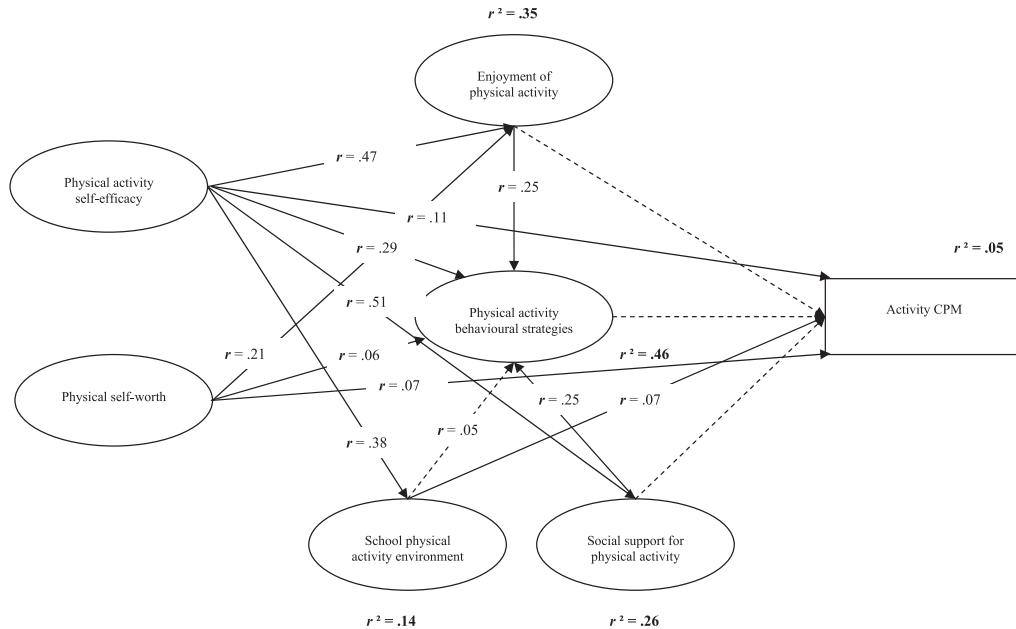


Fig. 2. Standardized parameter estimates for the model explaining adolescent girls' accelerometer CPM. Note: filled-in lines represent significant pathways and dotted lines represent non-significant pathways ($P > 0.05$).

portion of the variance in physical activity. Common method artefact may explain this finding, along with the weak correlations between behaviour and self-reported variables. Self-report measures of physical activity often result in the over-reporting of behaviour and generally result in greater amounts of variance explained [57]. Similar to the current study, Dishman *et al.* [38] found that the correlations between objectively measured physical activity and psychosocial constructs among girls in the Trial of Activity for Adolescent Girls study were much lower than previous studies that measured physical activity using self-report.

Self-efficacy has been identified as a consistent correlate and mediator of physical activity among adolescent girls [12, 13, 38]. In the current study, the path coefficient from self-efficacy to objectively measured physical activity was the strongest of all associations. Self-efficacy represents the central determinant of behaviour because it has both direct and indirect influences on health behaviour [2]. Based on a test of joint significance,

which requires that the path from the predictor to the mediator and the path from the mediator to the outcome to be statistically significant [58], physical activity environment mediated the relationship between self-efficacy and physical activity. This finding indicates the potential indirect effect of self-efficacy on behaviour. According to Bandura [1], there are four main sources which provide individuals with information regarding self-efficacy beliefs (prior success and performance attainment, imitation and modelling, verbal and social persuasion and judgments on physiological states) and all these should be targeted in physical activity interventions.

While perceptions of social support are thought to influence physical activity in adolescent girls [12, 59], in the current study, the pathway from social support to physical activity was not significant. Consistent with Bandura's SCT [2] and previous studies with adolescent girls [39, 60], the pathway from self-efficacy to social support was significant. In this study, social support was measured using

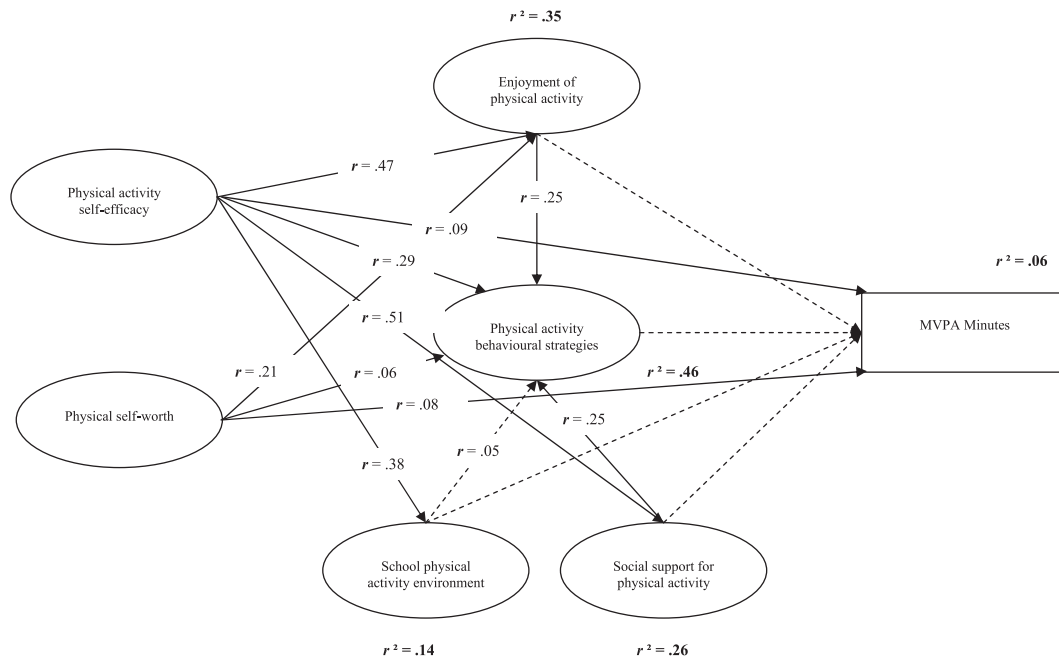


Fig. 3. Standardized parameter estimates for the model explaining adolescent girls' MVPA minutes. Note: filled-in lines represent significant pathways and dotted lines represent non-significant pathways ($P > .05$).

an existing peer support scale [47] and did not include the items referring to support from family members. It is likely that social support from both friends and family members is needed to prevent the decline in activity observed among adolescent girls [11]. Dowda *et al.* [60] found that changes in social support were associated with changes in physical activity among this population and concluded that perceived family support during adolescence may be an important factor influencing subsequent activity levels. More research focused on exploring the types and sources of social support relevant to adolescent girls is recommended.

Girls' perceptions of their schools' physical environment were assessed and included in the model. While the pathway from environment to physical activity was not statistically significant in the model predicting time in MVPA, it was significant in the model predicting CPM. One possible explanation for this finding is that the school environment contributes more to girls' low intensity activity than

their MVPA. Adolescents spend a large amount of their waking hours during school terms in school and it appears that their physical environments have the potential to influence activity [18]. Additional environmental components, such as home and neighbourhood characteristics, may help to explain additional physical activity variance in adolescent girls and should be included in future models.

Unlike Bandura's SCT, our model included physical self-worth. Physical self-worth is the evaluative component of self-concept which is a multi-dimensional construct. All the physical self-concept subscales (i.e. sport competence, body attractiveness, physical condition and strength) were associated with physical activity in the bivariate correlations. In addition, physical self-worth was significantly associated with physical activity in the tested models. Physical self-worth is an important contributor to global self-esteem and evidence suggests that self-concept declines from preadolescence to mid-adolescence [61]. Physical activity

also declines during this period [11] and both cross-sectional and longitudinal studies have found positive associations between physical self-concept and physical activity in adolescent girls [33, 51]. Yet, it remains unclear which dimensions of physical self-concept are most important for predicting behaviour among adolescent girls. Biddle and Fuchs [32] suggest that issues of body image and appearance are important for adolescent girls in the context of physical activity decision making. Adolescents' confidence in their ability and their actual ability to perform motor skills have also been linked to adolescents' physical activity levels [22]. A feedback loop between physical self-concept and physical activity may exist, whereby adolescents require a certain level of physical self-concept to feel comfortable about participating in activity and then through increased participation their physical self-concept may improve. Based on their findings from a cohort of 1250 adolescent girls, Dishman *et al.* [51] suggested that physical activity has a unique positive influence on physical self-concept which operates independently of perceptions of appearance. The relationship between physical self-worth and physical activity is complicated. We originally tested a non-recursive model with bidirectional arrows between physical self-worth and physical activity. However, the stability index was >1 indicating that the results were unstable and should not be reported. Further studies exploring physical self-concept as both a mediator and an outcome of physical activity may help elucidate the role of physical self-concept in adolescent populations. This may be achieved by testing a bidirectional relationship between self-worth and physical activity in the conceptual model.

Strengths and limitations

This is one of a small number of studies to test a model of physical activity behaviour in adolescent girls using an objective measure (accelerometers). The study sample included a large number of girls from a broad cross-section of schools (urban/rural drawn from low and high socio-economic status neighbourhoods, single-sex and co-educational). However, there are

a number of limitations that should be noted. Firstly, not all the scales used in the current analysis reflected the proposed constructs in their entirety. Although the school physical activity environment scale used in the current study addressed some aspects of school policy, such as the availability of facilities and equipment, additional relevant physical activity policies were not included (e.g. uniforms, school culture/support for physical activity and policies for recess and lunch use of time). Secondly, we have not reported extensive demographic information for the study participants and the data were collected from girls in Grade 8 only. However, the proposed model was designed to be a model of behaviour for all adolescent girls. Future studies may choose to test the model among adolescent girls from different ethnic and racial groups and include a more extensive adolescent age span.

Conclusions

Evidence suggests that girls are less active than boys in almost every age group [10] and the decline in physical activity associated with adolescence is more precipitous among girls [11]. In addition, the correlates and predictors of physical activity vary between boys and girls [12] and motivating adolescent girls to be adequately active is a challenge for many physical educators. For these reasons, the development and evaluation of a theoretical model of physical activity for adolescent girls are important contributions to the literature. The conceptual model proposed in this paper provides flexibility in regards to which scales (e.g. family support instead of peer support) are included and may help guide a broad range of interventions for adolescent girls. While certain constructs such as self-efficacy and behavioural strategies are central to the proposed theory, different types of outcome expectations and barriers and facilitators should be selected based on the target sample and intervention type. For example, a parent-based intervention designed to promote physical activity among adolescent girls should include items relating to parental support for physical activity rather than peer support. This

flexibility will help to reduce respondent burden by minimizing the number of scales completed by participants and improve the possibility of identifying mediation effects.

Unfortunately, the tested model could only explain a small proportion of the variance in physical activity. The model requires further refinement and the addition of specific environmental components, such as the availability of facilities and equipment at home and in the community, may help improve the explanatory power of the model.

Behavioural strategies have emerged as potential mechanisms of behaviour change in youth interventions [25, 62]. However, the behavioural strategies scale used in the current study was originally developed for adults and might not accurately reflect the strategies used by adolescents. A more contemporary measure that reflects the importance of technology in the lives of adolescent girls may improve the explanatory power of this construct. For example, girls who use pedometers to monitor their activity and listen to i-Pods while walking to make the activity more enjoyable may be more active than those who do not. These hypotheses should be tested in future studies and interventions focusing on specific behavioural strategies. While the displacement hypothesis proposes that time spent in sedentary behaviour (e.g. television viewing, using the computer and playing electronic games) replaces physical activity time [63], others have argued that they are different behaviours with different correlates [63]. Despite the lack of consensus on this issue, sedentary behaviour may be considered a barrier to physical activity and could be included in future permutations of the conceptual model proposed.

Alternatively, social cognitive models may be less appropriate for this age group or new strategies for measuring constructs may be required. For example, interviewer-administered questionnaires may help to improve adolescents' understanding of the hypothesized constructs, which may improve the explanatory powers of existing scales. Young adolescents may not possess the necessary cognitive abilities to understand the psychological processes influencing their behaviours. Explaining adolescents girls' physical activity behaviour is

challenging and further testing of existing and new models using objective measures of physical activity is warranted. Future researchers are encouraged to assess physical activity using objective and subjective measures to further explore the possibility of common method artefact.

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Conflict of interest statement

None declared.

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