Abstract

Objectives: The purpose of this study was to explore potential moderators and mediators of intervention effects in the Physical Activity Leaders (PALs) obesity prevention program for adolescent boys from disadvantaged secondary schools.

Design: Group randomized controlled trial.

Method: One hundred adolescent boys (mean age = 14.3 (0.6) years) from four schools were randomized to the PALs intervention or a control group for the 6-month study period. The primary outcome was change in BMI and secondary outcomes were physical activity assessed using pedometers and constructs from Social Cognitive Theory (SCT) assessed using a questionnaire.

Results: Moderation analyses revealed a significant weight status interaction for BMI ($p=0.04$), indicating stronger intervention effects for youth classified as overweight/obese at baseline. The intervention had a significant effect on resistance training self-efficacy ($p<0.001$), but none of the SCT constructs satisfied the criteria for mediation. The number of intervention sessions attended was associated with changes in BMI ($r= -0.38$, $p=0.001$), resistance training self-efficacy ($r=0.42$, $p<0.001$) and physical activity behavioral strategies ($r=0.26$, $p=0.018$). Changes in BMI were also associated with changes in resistance training self-efficacy ($r= -0.21$, $p=0.06$) and physical activity behavioral strategies ($r= -0.29$, $p=0.009$).

Conclusions: A school-based intervention incorporating student leadership increased adolescent boys' resistance training self-efficacy, but changes in physical activity were not detected and none of the SCT constructs satisfied the criteria for mediation. Baseline weight status was a moderator of intervention effect with the strongest intervention effects observed among overweight and obese adolescent boys.

Key Words: Overweight, Intervention; Theory; Strength Training; Body Composition; Resistance Training

Introduction

The prevalence of pediatric obesity in many developed countries has increased rapidly over the past 30 years and current estimates suggest that approximately 25% of youth in developed nations are overweight or obese[1, 2]. Obesity has a strong socio-economic gradient and higher rates of obesity have been observed in low-income communities[1]. Schools have been identified as important institutions for the promotion of physical activity and healthy eating and the prevention of obesity among youth[3] have been evaluated in numerous small and large-scale randomized controlled trials[3]. Although these interventions have achieved some degree of success, a poor understanding of the causal mechanisms of behavior change has hindered the development of effective interventions[4, 5].

Mediation analyses assist in the interpretation of intervention effects by identifying the mechanisms of behavior change. In the context of an obesity prevention program, mediators are the intervening causal variables necessary to complete the pathway from the intervention to health behavior change[6]. Moderating variables are not part of the causal chain but may influence the effect or strength of an intervention on the targeted outcome. Moderation analyses help to determine which types of interventions are successful in various subgroups. The importance of exploring potential mediators and moderators in obesity prevention trials has been noted in the literature[4, 5, 7].

The purpose of the current study was to explore mediators and moderators in the Physical Activity Leaders (PALs) for low-active adolescent boys from disadvantaged secondary schools. Poor dietary behaviors and insufficient physical activity contribute to the high prevalence of obesity among adolescent boys living in low-income communities[1]. Obesity tracks into adulthood[8] and in Australia, young men are more likely to be overweight than young women[9]. Consequently, adolescent boys living in low-income communities are at a high risk of obesity and interventions targeting this group are clearly warranted. The PALs intervention resulted in significant improvements in body composition, which have been described in detail elsewhere[10].

Methods

Study design and sample size. The PALs intervention was evaluated using a group randomized controlled trial. Assessments were conducted at baseline, 3- and 6-months. The reporting of this study conforms to the Consolidated Standards of Reporting Trials (CONSORT) guidelines for randomized

trials and was registered with the Australia and New Zealand Clinical Trials registry (ACTRN12609000414213). Ethics approval for this study was obtained from both the University of Newcastle and the NSW Department of Education & Training (DET) ethics' committees. Participants and their parents provided written informed consent prior to participation and the study was conducted from June to December 2009. The study was adequately powered to detect a between group difference of 2000 steps and medium-sized mediation effects using a product-of-coefficients test[11].

Setting and participants. Six low socio-economic status (SES) secondary schools from the Hunter Region, NSW, Australia identified using the NSW DET Priority Schools Program (PSP) classification were invited to participate in the study, and four schools consented to participate. The PSP was set up in 2006 by the state government to identify disadvantaged schools and provide them with additional funding, staffing and consultancy to support students attending schools in low-income communities. The decision to include schools in the PSP is made by the NSW DET and is based on the level of employment, education, and Indigenous status of the schools' parents. Participants were adolescent boys in Grade 9 attending one of the four study schools. Physical education (PE) teachers at these schools assisted in identifying and recruiting low-active boys. Following baseline assessments, a member of the research team used a randomization envelope to determine whether schools were allocated to the intervention or wait list control groups.

Treatment conditions. The PALs program[10] was a multi-component school-based intervention that included school sport sessions, physical activity and nutrition handbooks, interactive seminars, lunch-time activities, leadership sessions, and pedometers for self-monitoring[12]. The program was guided by SCT[13] and the intervention components involved a variety of behavior change strategies focused on the promotion of lifetime and lifestyle activities. A full description of the intervention components, the behavior change strategies and targeted constructs are provided in Table 1. A unique aspect of the PALs program was that it encouraged boys to become physical activity leaders in their schools and at home.

Outcomes. Research assistants (RAs) conducted all assessments, which were completed at the study schools using the same instruments at each time point. Height was measured using a portable stadiometer (Design No. 1013522, Surgical and Medical Products, Australia) and weight was

measured using a portable digital scale (Seca 770, Wedderburn). Body mass index (BMI) was calculated (weight[kg]/height[m]^2). Age-specific cut-off points were used to classify participants as healthy weight, overweight or obese[14]. Yamax CW200 pedometers (Yamax Corporation, Kumamoto City, Japan) have good validity[15] and were used to provide five days (four consecutive school days and one weekend day) of activity. Students were instructed by a RA on how to attach the pedometers and asked to remove the pedometers only when sleeping or when the pedometer might get wet. Participants were instructed to remove their pedometers at the end of the day, record their daily step counts, reset their pedometers to zero and record if they had removed their pedometer for any reason. Excessively high (>30,000) and low (<1000) step counts were replaced using the mean of valid days and values were imputed for non-ambulatory activity such as resistance training.

Hypothesized moderators. Physical activity, fitness level and weight status at baseline were tested as potential moderators of the PALs intervention on BMI. It was hypothesized that the intervention would have the largest effects among overweight, low-fit and low-active individuals. The International Obesity Task Force cut-points were used classify participants and results from the 90º push-up test (90PU) were used to classify the participants as low fit (bottom 50%) or high fit (top 50%)[16]. Participants' baseline physical activity (i.e. mean steps/day) was also tested as a potential moderator of intervention effects. Weight status and fitness were also tested as potential moderators of intervention effects on physical activity.

Hypothesized mediators. The following mediators were assessed using existing instruments: physical activity self-efficacy[17], resistance training self-efficacy[18], peer support for physical activity[19] and physical activity behavioral strategies[20]. To reduce respondent burden, we only measured constructs that we believed would change as a result of the intervention and in turn, would mediate the effect of the program. Based on our experience and evidence from the literature[5], we hypothesized that both intentions and outcome expectations would be high at baseline and would not mediate changes in behavior and therefore these constructs were not measured. The intervention still included information about the importance of physical activity to improve outcome expectations and behavioral strategies to increase intention (participants use of behavioral strategies were measured). The descriptions, sources and psychometric properties of the scales are reported in Table 2.

Analyses. Statistical analyses were completed using PASW Statistics 17 (SPSS Inc. Chicago, IL) software. Alpha levels were set at $p<0.05$ and analyses were conducted using the intention-to-treat principle. Linear mixed models fitted with an unstructured covariance were used to assess the impact of group (i.e. intervention or control), time (treated as categorical with levels baseline, 3-months and 6-months) and the group by time interaction for the primary outcome (i.e. BMI). To examine the potential clustering of effects at the school level, treatment and treatment by time were nested in the school condition and included as a fixed effect. School attended did not significantly contribute to the model and was therefore removed. Analysis of moderation effects were undertaken by including a three-way interaction term (i.e., group by time by moderator). Stratified sub-group (e.g. healthy weight or overweight/obese) analyses were only conducted if the interaction term p-value was less than 0.10[21]. Cohen's *d* was used to determine the size of the intervention effects in the sub-groups.

A product-of-coefficients test was used to test single mediator models because it has good statistical power in small samples and can be used to identify significant mediation effects even in the presence of a non-significant intervention effect. The action theory test was calculated by regressing the potential mediators (A coefficient) onto treatment condition, controlling for baseline. The effect of the intervention on physical activity was estimated by regressing the posttest physical activity scores onto treatment condition (C´ coefficient) with adjustment for baseline scores and potential mediators. This model also provided the conceptual theory test which represents the association between changes in potential mediators (B coefficient) and changes in physical activity. Finally, the mediated effect was calculated by multiplying A and B and asymmetric confidence intervals were used to test the significance of the product-of-coefficients (AB) using Mackinnon and colleagues PRODCLIN program. Attendance at school sport and lunch time sessions was not compulsory and thus provides a proxy for school-based activity completed by participants over the study period. Bivariate correlation was used to examine the relationship between number of intervention sessions attended and changes in BMI and psychosocial mediators.

Results

Overview. The mean (SD) age of participants was 14.3(0.6) years and all participants were born in Australia and spoke English at home. There were no significant differences between

completers and study drop-outs for any of the study variables (p>0.05). Retention rate at 6-months was 82% (four participants withdrew from the intervention group, while nine and five participants were not available for the 6-month follow-up from the intervention and control groups, respectively). At baseline, 35% of participants were considered overweight or obese (20 in control and intervention groups, respectively).

Intervention effects. Overall intervention effects have been reported elsewhere[10]. In summary, significant group-by-time interaction effects were found for BMI (adjusted mean difference = -0.8 kg/m^{-2}, p<0.001), BMI z-score (adjusted mean difference = -0.2, p<0.001), and body fat (adjusted mean difference = -1.8%, p<0.05), but not for waist circumference, muscular fitness or physical activity.

Moderation effects. Significant interaction effects were found between weight status at baseline and the intervention effect on BMI (p=0.04). Sub-group analyses revealed stronger intervention effects among overweight/obese participants (-1.46 kg/m^2, [-2.40 to -0.52], p=0.01, d= -0.99) compared to those in the healthy weight group (-0.42 kg/m^2, [-0.76 to -0.08], p=0.003, d= -0.66). No significant interaction effects were found for fitness (p=0.46) or activity level (p=0.15) at baseline. Weight (p=0.55) and fitness (p=0.72) status at baseline were not moderators of intervention effects on physical activity.

Mediation effects. Mediation results are presented in Table 3. The intervention did not have a statistically significant effect on physical activity. The action theory test revealed a significant beneficial intervention effect for resistance training self-efficacy (A=0.47, 95% CI=0.27 to 0.67, p<0.001). The intervention had a positive effect on physical activity behavioral and a small non-significant negative effect on social support, both of which approached statistical significance. None of the results from the conceptual theory tests approached statistical significance and none of the variables satisfied the criteria for mediation. The number of intervention sessions attended was associated with changes in BMI (r= -0.38, p=0.001), resistance training self-efficacy (r =0.42, p<0.001) and physical activity behavioral strategies (r =0.26, p=0.018). Changes in BMI were also associated with changes in resistance training self-efficacy (r= -0.21, p=0.06) and physical activity behavioral strategies (r= -0.29, p=0.009).

Conclusion

The purpose of this study was to explore potential moderators and mediators of intervention effects in the PALs obesity prevention program for boys from schools in low-income communities. Weight status at baseline was a moderator of intervention effects, which were strongest among individuals classified as overweight or obese. The intervention resulted in significant increases in resistance training self-efficacy and changes in this outcome were associated with session attendance and improvements in BMI. However, we were not able to detect changes in physical activity and none of the variables satisfied the criteria for mediation.

The PALs intervention was designed for low-active adolescent boys and included boys who were both a healthy weight and overweight/obese. Intervention effects did not differ by pre-program fitness or activity level, but baseline weight status was a significant moderator, with the strongest effects observed among overweight and obese participants. A recent review of the moderators of school-based energy balance interventions found little evidence for baseline weight status as a moderator of effects[7] and also reported that interventions were generally more successful in girls than boys. By comparison, the 'Intervention Centered on Adolescents' Physical Activity and Sedentary behavior' was successful in preventing unhealthy weight gain in initially non-overweight adolescents, but not in adolescents who were already overweight[22]. Unlike previous programs, PALs was designed for low-active adolescent boys and included a range of strategies to motivate individuals disengaged from the traditional activities offered in secondary schools. Overweight adolescents are at an increased risk of becoming obese adults[8] and our findings suggest that the PALs intervention is an appropriate strategy for preventing unhealthy weight gain in overweight boys.

The PALs intervention did not increase physical activity, as measured by pedometers, and we offer a number of explanations for this finding. First, it is possible that the boys were engaged by the resistance training component of the intervention, but did not engage with the pedometer-based walking program. Second, artificially high baseline values in both groups, possibly due to reactivity[23], may also explain our failure to increase step counts over the study period. Evidence for reactivity to pedometer monitoring is equivocal and further study of adolescents' behavior is required. Finally, although participants were instructed to record their participation in non-ambulatory activity in their pedometer log

books, very few participants provided this information and therefore step counts did not necessarily provide an accurate reflection of participants' habitual physical activity.

We were unable to detect any significant mediators of physical activity behavior change. Mediation analyses that include physical activity as the targeted outcome are limited by the cross-sectional nature of the data collected at assessment points. For example, physical activity level assessed using pedometers or accelerometers provide a record of how much activity the participant completing during the monitoring period (typically 4-7 days). This method of assessment relies heavily on the assumption that the monitoring period is an accurate reflection of their usual activity, however, studies have found substantial intra-individual variation in objectively measured physical activity in youth[24]. For these reasons, we also examined the relationship between participants' attendance and changes in BMI and psychosocial outcomes. We found that attendance at school sport and lunchtime sessions was associated with improvements in BMI, resistance training self-efficacy and physical activity behavioral strategies.

The PALs intervention included an information component designed to help participants identify and overcome their barriers to physical activity. It was hypothesized that participants would increase their confidence to be active, which would result in increased physical activity levels and reduced adiposity. This hypothesis was not confirmed, as physical activity self-efficacy did not change as a result of the intervention. Although few obesity prevention programs have specifically targeted adolescent boys, previous interventions have identified self-efficacy to be an important mediator of behavior change in physical activity for adolescent girls[5]. For example, self-efficacy partially mediated the effects of the Lifestyle Education for Activity Program for adolescent girls conducted in 24 middle schools in the United States[25]. Alternatively, self-efficacy did not change as a result of the theory-based physical activity intervention for Portuguese adolescents[26], but results were not stratified by gender. Compared to girls, adolescent boys are less likely to report a large number of barriers to activity[27] and ceiling effects might explain our failure to identify significant changes in self-efficacy, as baseline scores were relatively high (3.5/5). Social support also did not change as a result of the intervention. Participants were encouraged to provide social support for their friends and family members at school and in the home setting. Contrary to our hypothesis, participants' perceived peer support decreased over the study period. This finding may be explained by participants' heightened

awareness of the importance of social support after participating in the program.

Participants in the PALs intervention were provided with pedometers and encouraged to set physical activity goals and self-monitor their behavior. Participants' use of physical activity behavioral strategies increased over the study period but changes were not statistically significant. Self-monitoring with pedometers has emerged as a useful strategy for increasing physical activity in children and adolescents[12]. Similar to the current study, the Program X intervention was a school-based intervention for adolescents that combined health-related fitness activities with pedometers for self-monitoring[28]. Although the intervention was successful in increasing steps per day, the use of behavioral strategies did not mediate changes in behavior[29]. Future research is encouraged to explore the role of behavioral strategies in obesity prevention programs targeting adolescent boys.

This is the first study to examine potential mediators of change in a school-based intervention for Australian adolescent boys from schools in low-income communities. There are some limitations that should be noted. Fist, we did not examine mediators of dietary behavior change. Although the PALs intervention included an information component designed to encourage healthy eating behaviors, the intervention was biased toward physical activity and no dietary mediators were assessed. Second, PE teachers at the study schools were asked to identify and recruit students who they considered to be disengaged in PE and/or not currently participating in organized team or individual sports. Finally, the study was under powered to detect moderation effects and small changes in physical activity and hypothesized mediators.

A school-based intervention incorporating student leadership improved adolescent boys' body composition, with the strongest intervention effects observed among those classified as overweight/obese at baseline. The intervention increased participants' resistance training self-efficacy, which was associated with changes in BMI. However, changes in physical activity were not detected and none of the SCT constructs satisfied the criteria for mediation. Using students as physical activity leaders appears to be an appropriate strategy for engaging low-active adolescent boys to improve their health-related fitness. Additional strategies may be required to increase boys' incidental physical activity and considering the small numbers of high school students who walk or ride to school, strategies focusing on active transportation are warranted. This is one of few studies to examine the

potential mediators of objectively measured physical activity[29, 30] in an adolescent population and future studies are encouraged to explore the mechanisms of behavior change in larger scale trials using accelerometers.

Practical implications

- Resistance training is an effective strategy for inducing healthy weight loss in overweight boys.
- Theory-based interventions are encouraged to operationalize their interventions and test mediators of physical activity behavior change.
- Hypothesized mediators of behavior change should align with the intervention components and behavior change strategies.

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References

1. Department of Health & Ageing. *2007 Australian National Children's Nutrition and Physical Activity Survey - Main Findings.* ACT: Commonwealth of Australia; 2008.

2. Lobstein T, Frelut ML. Prevalence of overweight among children in Europe. *Obes Rev* 2003;4:195-200.

3. Brown T, Summerbell C. Systematic review of school-based interventions that focus on changing dietary intake and physical activity levels to prevent childhood obesity: an update to the obesity guidance produced by the National Institute for Health and Clinical Excellence. *Obes Rev* 2009;10:110-141.

4. Cerin E, Barnett A, Baranowski T. Testing theories of dietary behavior change in youth using the mediating variable model with intervention programs. *J Nutr Educ Behav* 2009;41:309-318.

5. Lubans DR, Foster C, Biddle SJH. A review of mediators of behavior in interventions to promote physical activity among children and adolescents. *Prev Med* 2008;47:463-470.

6. Bauman AE, Sallis JF, Dzewaltowski DA et al. Toward a better understanding of the influences on physical activity - The role of determinants, correlates, causal variables, mediators, moderators, and confounders. *Am J Prev Med* 2002;23(2 Supp):5-14.

7. Yildirim M, van Stralen MM, Chinapaw MJ et al. For whom and under what circumstances do school-based energy balance behavior interventions work? Systematic review on moderators. *Int J Pediatr Obes* 2011;6(2):46-57.

8. Wang LY, Chyen D, Lee S et al. The association between body mass index in adolescence and obesity in adulthood. *J Adolesc Health* 2008;42(5):512-518.

9. Cameron AJ, Welborn TA, Zimmet PZ et al. Overweight and obesity in Australia: the 1999-2000 Australian Diabetes, Obesity and Lifestyle Study (AusDiab). *Med J Aust* 2003;178(9):427-432.

10. Lubans DR, Morgan PJ, Aguiar E et al. Randomized controlled trial of the Physical Activity Leaders (PALs) program for low-active adolescent boys from disadvantaged secondary schools. *Prev Med* 2011;52:239-246.

11. Fritz MS, MacKinnon DP. Required sample size to detect the mediated effect. *Psychol Sci* 2007;18(3):233-239.

12. Lubans DR, Morgan PJ, Tudor-Locke C. A systematic review of studies using pedometers to promote physical activity among youth. *Prev Med* 2009;48:307–315.

13. Bandura A. Health promotion by social cognitive means. *Health Educ Behav* 2004;31:143-164.

14. Cole TJ, Bellizzi MC, Flegal KM et al. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* 2000;320(7244):1240-.

15. Crouter SE, Schneider PL, Karabulut M et al. Validity of 10 electronic pedometers for measuring steps, distance, and energy cost. *Med Sci Sports Exerc* 2003;35(8):1455-1460.

16. Lubans DR, Morgan PJ, Callister R et al. Test-retest reliability of a battery of field-based health-related fitness measures for adolescents. *J Sports Sci* 2011;29(7):685-693.

17. Motl RW, Dishman RK, Trost SG et al. Factorial validity and invariance of questionnaires measuring social-cognitive determinants of physical activity among adolescent girls. *Prev Med* 2000;31(5):584-594.

18. Lubans DR, Aguiar E, Callister R. The effects of free weights and elastic tubing resistance training on physical self-perception in adolescents. *Psych Sport Exerc* 2010;11(6):497-504.

19. Sallis JF, Taylor WC, Dowda M et al. Correlates of vigorous physical activity for children in grades 1 through 12: Comparing parent-reported and objectively measured physical activity. *Pediatr Exerc Sci* 2002;14(1):30-44.

20. Saelens BE, Gehrman CA, Sallis JF et al. Use of self-management strategies in a 2-year cognitive-behavioral intervention to promote physical activity. *Behav Ther* 2000;31:365-379.

21. Assmann SF, Pocock SJ, Enos LE et al. Subgroup analysis and other (mis)uses of baseline data in clinical trials. *Subgroup analysis and other (mis)uses of baseline data in clinical trials* 2000;355(9209):1064-1069.

22. Simon C, Schweitzer B, Oujaa M et al. Successful overweight prevention in adolescents by increasing physical activity: a 4-year randomized controlled intervention. *Int J Obes* 2008;32:1489-1498.

23. Clemes SA, Matchett N, Wane SL. Reactivity: An issue for short-term pedometer studies? *Br J Sports Med* 2008;42:68-70.

24. Mattocks C, Leary S, Ness A et al. Intraindividual variation of objectively measured physical activity in children. *Med Sci Sports Exerc* 2007;39(4):622-629.

25. Dishman RK, Motl RW, Saunders R et al. Self-efficacy partially mediates the effect of a school-based physical-activity intervention among adolescent girls. *Prev Med* 2004;38(5):628-636.

26. Araújo-Soares V, McIntyre T, MacLennan G et al. Development and exploratory cluster-randomised opportunistic trial of a theory-based intervention to enhance physical activity among adolescents. *Psychol Health* 2009;24(7):805-822.

27. Van der Horst K, Paw MJCA, Twisk JWR et al. A brief review on correlates of physical activity and sedentariness in youth. *Med Sci Sports Exerc* 2007;39(8):1241-1250.

28. Lubans DR, Morgan PJ, Callister R et al. Effects of integrating pedometers, parental materials, and email support within an extracurricular school sport intervention. *J Adolesc Health* 2009;44(2):176-183.

29. Lubans DR, Morgan PJ, Callister R et al. Exploring the mechanisms of physical activity and dietary behavior change in the Program X intervention for adolescents. *J Adolesc Health* 2010;47(1):83-91.

30. Lytle LA, Murray DM, Eveneson KR et al. Mediators affecting girls' level of physical activity outside of school: findings from trhe Trial of Activity for Adolescent Girls. *Ann Behav Med* 2009;38:124-136.

Table 1: Intervention components, behavior change techniques and targeted constructs

Intervention component	Behavior change strategies	Target variables
Enhanced school sports sessions (10 x 90 minutes sessions): Sessions were delivered by teachers and involved an information component (10-15 minutes) and a physical activity session (75-80 minutes). The information component included physical activity and nutrition recommendations, benefits and key behaviors. Teacher-directed physical activity sessions included resistance training using elastic tubing devices (Gymstick™ International, Lahti, Finland), circuit training and boxing style fitness activities. Participants were give feedback about their physical activity and fitness results in the interactive seminars by members of the research team and were encouraged to set individualised daily step goals using their baseline pedometer results.	* Prompt specific goal setting * Information on consequences * Prompt intention formation * Provide instruction * Barrier identification * General encouragement * Graded tasks	OE, SS, TSE, BSE, SR
Interactive seminars (3 x 30 minutes): Participants attended interactive seminars delivered by members of the research team. Interactive seminars addressed key physical activity and nutrition behaviors and leadership principles. The leadership seminars emphasized the qualities of good leaders and provided students with an opportunity to develop their leadership and instruction skills.	* Provide information about behavior health link * Prompt self-monitoring of behaviors * Plan social support or social change * Barrier identification	OE, SS, BSE, SR
Lunch-time activity sessions (8 x 30 minutes): Students participated in self-directed physical activity sessions involving elastic tubing resistance training. Sessions were supervised by teachers but were organized and run by students.	* Model or demonstrate the behavior * Graded tasks	TSE, SS
Physical activity and nutrition handbooks (9 weeks): Participants were provided with physical activity and nutrition handbooks, which included information and home challenges designed to promote physical activity and healthy eating for parents and participants.	* Provide information about behavior health link * Prompt self-monitoring of behaviors * Plan social support or social change	INT, BSE, OE, SR
Physical activity leadership sessions (6 x 30 minutes): Participants were required to recruit and instruct Grade 7 students on how to safely use the elastic tubing resistance training devices.	* Model or demonstrate the behavior * Prompt identification as a role model * General encouragement * Graded tasks	TSE, SS
Pedometers for self-monitoring (6 months): Participants were provided with Yamax CW200 pedometers and taught goal setting and self-monitoring behaviors. Participants were encouraged to set individualized pedometer step goals using their baseline step counts.	* Prompt self-monitoring of PA * Prompt specific goal setting	SR

Note. OE = outcome expectations; SS = social support, TSE = task self-efficacy, BSE = barrier self-efficacy, SR = self-regulation

Table 2: Description and psychometric properties of hypothesized mediator scales

Hypothesized mediators	Description of scale	Range (No. of items)	Source	Psychometric properties
Physical activity self-efficacy	Students were asked to rate how confident they were that they could 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 is hot or cold outside". Scale: 1 = *Disagree a lot* to 5 = *Agree a lot*	1-5 (8)	Motl et al (2000)	α = 0.84 ICC = 0.89
Resistance training self-efficacy	Students were asked to rate their confidence to complete resistance training in a variety of circumstances. Example item: "I can complete resistance training exercises without the help of someone else (e.g. friend, trainer)" Scale: 1 = *Strongly disagree* to 5 = *Strongly agree*	1-5 (5)	Lubans et al (2010)	α = 0.63 ICC = 0.84
Physical activity behavioral strategies	Students were asked to indicate how often they used a variety of behavioral & cognitive strategies to increase their physical activity. The following common stem was provided: "How often do you use the following strategies to increase your motivation for 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 (8)	Saelens et al (2000)	α = 0.88 ICC= NA
Peer support for physical activity	Students 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 (5)	Sallis et al (2002)	α = 0.82 ICC = 0.81

Note. Test-retest reliability from cited sources; ICC = Intra class correlation for test-retest reliability; α = Cronbach's alpha derived from study sample; NA = not available.

Table 3: Action theory test, conceptual theory test and significance of the mediated effect at six months

Hypothesized mediators	Intervention effect	Action theory test		Conceptual theory test		Significance of mediated effect	
	C´(SE)	A (SE)	95% CI	B (SE)	95% CI	AB	95% CI[1]
Physical activity self-efficacy	-602 (1027)	-0.06 (.09)	-0.25 to 0.12	479 (1379)	-2296 to 3254	-29	-329 to 239
Resistance training self-efficacy	-1192 (1149)	.47 (.10)***	0.27 to 0.67	804 (1114)	-1439 to 3046	379	-635 to 1477
Peer support for physical activity	-478 (1047)	-0.25 (.15)	-0.54 to 0.04	1230 (886)	-553 to 3013	-308	-1003 to 116
Physical activity behavioral strategies	-487 (1040)	0.20 (0.14)	-0.07 to 0.48	-131 (812)	-1766 to 1503	-26	-392 to 310

Note. C´ = unstandardized regression coefficient of the intervention predicting physical activity accounting for effect of the mediator; A = unstandardized regression coefficient of treatment condition predicting hypothesized mediators; B = unstandardized regression coefficient of the hypothesized mediator predicting physical activity with treatment condition included in the model; SE = standard error; 95% CI = 95% confidence interval; AB = product-of-coefficients estimate; [1]95% asymmetric confidence intervals of the mediated effect calculated using the PRODCLIN program.
***$p < 0.001$.

Supplementary Figure 1: Overview of mediation including pathways and coefficients