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TITLE

Psychological, Social and Physical Environmental Mediators of the SCORES Intervention on Physical Activity among Children living in Low-income Communities

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Abstract

Objectives: This study examined mediation effects of socio-ecological variables on accelerometer-determined physical activity among children in the Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES) intervention.

Design: Randomized control trial mediation analysis

Methods: Primary school children were randomly assigned the SCORES multi-component intervention or control group for the 12-month study. The outcome was accelerometer derived total moderate-to-vigorous physical activity (MVPA). Hypothesized mediators measured in children were physical activity enjoyment and perceived sport competence and social support. Hypothesized mediators measured in parents were family social support, access to physical activity facilities and equipment at home, and perceived access to physical activity opportunities in the local community. Mediation analyses were conducted using multi-level linear analysis in MPlus.

Results: There were significant intervention effects for social support from teachers ($A=1.73$, $SE=0.88$, $p=0.048$) and parental perceived access to physical opportunities in the local community ($A=2.69$, $SE=1.12$, $p=0.016$). There were significant associations between

changes in perceived sport competence ($B=0.48$, $SE=0.36$, $p=0.027$), parental perceived access to physical activity opportunities in the local community ($B=0.60$, $SE=0.26$, $p=0.021$), and changes in total MVPA. Parental perceived access to physical activity opportunities in the local community was found to have a significant mediating effect on total MVPA ($AB=1.61$, 95% $CI=0.06$ to 3.95 , proportion 13%).

Conclusions: Parental perceived access to physical activity opportunities in the local community is a potential mechanism of behavior change for children and mediated the effect of the SCORES intervention on objectively measured physical activity.

Key words: mediation; primary school; socio-ecological; multi-component

1. Introduction

Physical inactivity is a global public health concern, with 80% of youth not participating in adequate amounts of physical activity to gain the well-established physical, social, cognitive and psychological health benefits (Hallal et al., 2012; Tremblay et al., 2014)). The school setting has been identified as an important setting for the promotion of physical activity in children (Centers for Disease Control & Prevention, 2011; Dobbins, De Corby, Robeson, Husson, & Tirilis, 2009) and a number of school-based interventions aimed at increasing children's physical activity levels have been evaluated (Dobbins, Husson, DeCorby, & LaRocca, 2013; Kriemler et al., 2011; van Sluijs, McMinn, & Griffin, 2008)). Recent reviews have shown that high quality, multi-component approaches in schools can increase young people's physical activity (Dobbins et al., 2013; Kriemler et al., 2011; Sallis et al., 2012). While evaluating the effectiveness of school-based interventions is necessary, investigation of potential mediating variables (i.e., variables which explain the effect/relationship of dependent variables on the primary outcome variable) is vital for systematic progression of physical activity research and to further our understanding of how

interventions work (Bauman, Sallis, Dzewaltowski, & Owen, 2002; Brown, Hume, Pearson, & Salmon, 2013; D. R. Lubans, C. Foster, & S. J. H. Biddle, 2008b).

Mediation analysis can be used to determine whether an intervention was successful via the hypothesized mechanisms. This is particularly important when implementing and evaluating multi-component interventions, as mediation analysis allows researchers to identify the integral components of an intervention, which can help guide the design of future interventions (Bauman et al., 2002; Brown et al., 2013; Lubans et al., 2008b). While primary school physical activity interventions are common, few studies have evaluated the efficacy of multi-component Comprehensive School Physical Activity Programs that involve coordination across five components: (i) quality physical education (PE), (ii) activity during the school day, (iii) activity before and after school, (iv) staff involvement and (v) family and community involvement (Centers for Disease Control and Prevention, 2013; Hills, Dengel, & Lubans, 2015). Moreover, primary school physical activity interventions rarely investigate the effect of interventions on hypothesized mediators of behavior change. Of the few studies published, most have investigated psychological (e.g., self-efficacy, attitude and self-regulation) and social (e.g., social support from family, friends and teachers) mediators. Such studies have found evidence for the mediating effects of self-efficacy and intention on children's physical activity (van Stralen et al., 2011). However, overall, the lack of mediation studies conducted in the primary school setting has made it difficult to draw conclusions regarding the most effective mediators of physical activity behavior change in children (Lubans et al., 2008b; van Stralen et al., 2011). Of note, few studies (Eather, Morgan, & Lubans, 2013; Lubans, Morgan, Callister, Collins, & Plotnikoff, 2010; Lytle et al., 2009; Zizzi et al., 2006) have examined the impact of hypothesized mediators on objectively measured physical activity. This is a notable limitation, as physical activity is prone to self-report bias and common method artefact may artificially inflate mediation effect sizes

(Dishman, 1994). Moreover, there is a distinct lack of studies investigating environmental mediating variables (van Stralen et al., 2011), with the limited studies investigating the mediating effects of access to facilities among adolescent girls (Lytle et al., 2009) and the perceived school environment among children (Eather et al., 2013), both of which were found to be non-significant mediators of physical activity. Further investigation is needed, as there is strong evidence for physical environmental variables as correlates of children's physical activity and the importance of the physical environment is noted in health behavior change models (McLeroy, Bibeau, Steckler, & Glanz, 1988; Sallis, Owen, & Fisher, 2008).

The socio-ecological model, which highlights the important role of the social and physical environment in determining behavior (McLeroy et al., 1988), provided a framework for the Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES) intervention. SCORES was a 12-month multi-component school-based physical activity intervention (Lubans, Morgan, Weaver, et al., 2012). The intervention was successful in promoting physical activity (adjusted mean difference, 12.7 moderate-to-vigorous physical activity (MVPA) mins/day; 95% CI, 5.0 to 20.5), increasing cardiorespiratory fitness (5.4 laps; 95% CI, 2.3 to 8.6) and improving fundamental movement skills (4.9 units; 95% CI, -0.04 to 9.8) in primary school-aged children from low-income communities (Cohen, Morgan, Plotnikoff, Callister, & Lubans, 2014). Behavior change strategies for the intervention were guided by an integrated model involving elements of Self-Determination Theory (Deci & Ryan, 1985, 2000) and Competence Motivation Theory (S. Harter, 1985; Weiss, 2000).

The integrated model used in the SCORES intervention proposed that children who have high levels of perceived and actual movement skill competency, receive social support from significant others in their life, will enjoy physical activity and seek opportunities to be physically active in the future (Lubans, Morgan, Weaver, et al., 2012). Mediation effects of actual movement skill competency have been reported previously (Cohen, Morgan,

Plotnikoff, Barnett, & Lubans, 2015), and found that fundamental movement skill competency mediated the effect of the SCORES intervention on physical activity behavior. Therefore, the primary aim was to examine whether changes in individual (i.e., enjoyment and perceived competence), social (i.e., social support from teachers, parents and peers) and environmental (i.e., access to physical activity facilities, equipment, and opportunities in the local community) constructs from the theoretical models mediated physical activity changes in the SCORES intervention.

2. Materials and Methods

The SCORES intervention was evaluated using a cluster randomized controlled trial (RCT). The design, conduct, and reporting of this cluster RCT adhered to the Consolidated Standards of Reporting Trials guidelines for group trials (Campbell, Elbourne, & Altman, 2004). The trial was registered with the Australia and New Zealand Clinical Trials registry (registration number ACTRN12611001080910). Ethics approval for this study was obtained from the Human Research Ethics Committees of the University of Newcastle, Australia and the New South Wales (NSW) Department of Education and Communities. School principals, teachers, parents provided consent and study participants provided written informed assent. A detailed description of the design and methods of the SCORES cluster RCT has been reported previously (Lubans, Morgan, Weaver, et al., 2012). Data for the current study were used from the baseline (conducted February through March 2012) and post-test (12-months post baseline; conducted February through March 2013) assessments. From the original sample of 460, only individuals who provided useable data at both time points ($n = 101$) were used for analysis.

2.1 Setting and participants

The SCORES intervention was designed for children attending government primary schools located in low-income communities. The Socio-Economic Indexes for Areas (SEIFA) index of relative socioeconomic disadvantage (2) was used to identify eligible primary schools. To be eligible, primary schools were required to have a SEIFA index of ≤ 5 (lowest 50%). Eight primary schools (25 classes) from the Newcastle area, NSW, Australia consented to participate (50% consent rate). A total of 460 students (Grades 3 and 4; aged 7 to 10 years) assented to participate (78%).

The eight schools were match-paired (i.e. 4 pairs of schools) based on their size (number of students) and socio-economic status (SES) (based on post-code of school) after baseline assessments. An independent researcher using a computer-based random number producing algorithm randomized the pair-matched schools to control or intervention conditions. The schools were allocated to either the SCORES intervention or control group for the duration of the study. Assessors were blind to treatment allocation at baseline but not at follow-up assessments.

2.2 Study arms

The SCORES intervention has been described in detail previously (Lubans, Morgan, Weaver, et al., 2012). Briefly, SCORES was a 12-month multi-component physical activity and fundamental movement skill intervention for children attending primary schools in low-income communities. The socio-ecological model (McLeroy et al., 1988) provided a framework for the intervention and behavior change strategies were guided by Self-Determination Theory (Deci & Ryan, 1985, 2000) and Competence Motivation Theory (S. Harter, 1985; Weiss, 2000). The intervention included five components: i) professional learning workshops for teachers (effective teaching methods for the development and assessment of fundamental movement skills, increasing MVPA and enjoyment in physical

education and school sport based on the ‘SAAFE’ teaching principles), ii) student leadership (children were trained to be physical activity leaders in their school and encouraged to promote physical activity and fundamental movement skill development through completing a number of set up [i.e., equipment monitor], run [i.e., deliver break-time activities] and promote [i.e., speak on assembly] tasks), iii) policy and environment (six school physical activity policies were implemented and physical activity equipment packs and resources were provided), iv) parental engagement (newsletters, parent evening and weekly fundamental movement skill homework), and v) school-community links (local sporting organizations visited schools during physical education/school sport to promote community sporting links). The intervention strategies were aligned with socio-ecological mechanisms of behavior change, which are summarized in Table 1.

The control schools were requested to follow their usual physical education and school sport program for the 12-month study period.

2.3 Outcomes

Trained research assistants conducted all assessments, which were completed at the study schools. A protocol manual, which included specific instructions for conducting all assessments, was developed to standardize procedures and for quality assurance. The same research assistants and instruments were used at all time-points.

2.3.1 Physical activity

ActiGraph GT3X+ accelerometers (ActiGraph, LLC, Fort Walton Beach, FL) were used to assess children’s physical activity. Trained research assistants explained and fitted the accelerometers to the children following standardized accelerometer protocols (Trost, McIver, & Pate, 2005). Children were required to wear accelerometers during waking hours

for seven consecutive days, except while bathing and swimming. Accelerometer data was analyzed using MeterPlus version 4.3 software (Santech Inc., San Diego, US). Data were collected and stored in 10-second epochs with a frequency of 30 Hz. Valid wear time for total physical activity was defined as a minimum of three weekdays and a weekend day with at least eight hours (480 minutes/day) of total wear time recorded. Non-wear time was defined as strings of consecutive zeroes equating to 20 minutes. The mean activity counts per minute (CPM) were calculated and activity thresholds were used to calculate time spent in sedentary (≤ 25 counts), light (26-573 counts), moderate (574–1002 counts) and vigorous (≥ 1003 counts) activity (Evenson, Catellier, Gill, Ondrak, & McMurray, 2008).

2.4 Hypothesized mediators

An overview of the hypothesized mediators and the scale descriptions is provided in Table 1.

2.4.1 Enjoyment

Children completed the Physical Activity Enjoyment Scale (PACES) (Motl et al., 2001) to assess their enjoyment of physical activity. PACES is scored on a 5-point Likert-type scale, with responses ranging from 1 (*Disagree a lot*) to 5 (*Agree a lot*). Scores for the nine positively worded items were summed to obtain a total score for enjoyment. The internal consistency of the scale in the current study was $\alpha = 0.79$ (Table 1).

2.4.2 Perceived sport competence

Children completed the perceived competence sub-scale from Harter's Self-Perception Profile (SPP) (S. Harter, 1985) to assess their perceived sport competence. To reduce socially desirable responses, the SPP uses a four-choice structured alternative format. Children first decided which of the two statements best describes them and then chose

whether the statement was ‘*sort of true*’ or ‘*really true*’ for them. Each item was scored from 1 (*low perceived sport competence*) to 4 (*high perceived sport competence*). Scores were summed to obtain a total score for perceived sport competence. The internal consistency of the scale in the current study was $\alpha = 0.69$ (Table 1).

2.4.3 Social support

Children reported the social support for physical activity that they receive from family/household members and peers/friends using the scale developed for the Amherst Health and Activity Study (Sallis, Taylor, Dowda, Freedson, & Pate, 2002). Children also reported the social support for physical activity they receive from teachers using an existing scale (Lubans, Morgan, & McCormack, 2011). Each scale contained five items and all scales utilized a five-point Likert-type scale, with responses ranging from 1 (*Never*) to 5 (*Everyday/Always*). Scores were summed to obtain a total score for social support from family, social support from peers and social support from teachers. The internal consistencies of the scales in the current study were: social support from family $\alpha = 0.85$, social support from peers $\alpha = 0.65$ and social support from teachers $\alpha = 0.75$ (Table 1).

Parents (mom or dad) of children in the study reported the level of social support for physical activity they provide for their children using the Children’s Leisure Activities Study Survey (CLASS) (Telford, Salmon, Jolley, & Crawford, 2004). Scores were summed to obtain a total score social support from family (parent report). The internal consistency of the scale in the current study was $\alpha = 0.79$ (Table 1).

2.4.4 Environment

Parents of children in the study completed selected scales from the CLASS (Telford et al., 2004) to assess their child’s access to physical activity facilities and equipment in their

home, and perceived access to physical activity opportunities in the local community. Scores were summed to obtain a total score for access to facilities at home, access to equipment at home, and perceived access to physical activity opportunities in the local community. The internal consistencies of the scales in the current study were: access to facilities at home $\alpha = 0.60$, access to equipment at home $\alpha = 0.70$ and perceived access to physical activity opportunities in the local community $\alpha = 0.79$ (Table 1).

2.5 Demographics and weight status

Children completed a questionnaire to obtain demographic information including sex, age, and suburb. The SEIFA index of relative socioeconomic disadvantage (Australian Bureau of Statistics, 2011) based on the suburb of the child's residence was used to determine each child's SES. Children's height was measured using a portable stadiometer (Model no. PE087, Mentone Educational Centre, Australia) and recorded to the nearest 0.1 cm. Children's weight was measured using a portable digital scale (Model no. UC-321PC, A&D Company Ltd, Tokyo Japan) and recorded to the nearest 0.1 kg. Children's weight was measured in light clothing without shoes. Body mass index (BMI) was calculated using the standard equation ($\text{weight}[\text{kg}]/\text{height}[\text{m}]^2$) and BMI-z scores were calculated using the 'LMS' method.

2.6 Statistical analyses

The difference between groups at baseline, and differences between those who completed the study and those who did not was analyzed using Chi-square and independent samples t-tests in IBM SPSS Statistics for Windows (Version 20, SPSS Inc., IBM Corp., Armonk, NY). Multi-level linear analysis in MPlus (Version 7.2, Muthen and Muthen) was used to analyze intervention effects and conduct single mediation models. Two levels were defined in the multi-level analyses: 1) student and 2) class. Established prior, children's sex,

age, BMI-z score, SES and baseline physical activity values were included as covariates, and all analyses were adjusted for these. Analyses were conducted for children who provided useable data at baseline and post-test.

The product-of-coefficient mediation analysis was conducted which involved three stages (Figure 1). Stage 1, was calculated by regressing the hypothesized mediators onto treatment condition (A coefficient). Stage 2, involved regressing physical activity onto treatment condition and the hypothesized mediators (B coefficient). This model also generates the direct effect of the intervention on physical activity after controlling for the mediators (C' coefficient). Stage 3, used the R Mediation package. The R Mediation package produces confidence intervals for the product of coefficients using methods based on: i) the distribution of product, ii) Monte Carlo simulations, and iii) an asymptotic normal distribution. Therefore, this approach is recommended over the bootstrap methods, especially for smaller samples (Tofighi & MacKinnon, 2011). The 95% confidence intervals for the product-of-coefficients (AB) must not include zero for a variable to satisfy the criteria for mediation. The formula $[AB/(C' + AB)]$ was used to calculate the proportion of the total effect that was mediated.

2.6.1 Supplementary analysis

Consistent with the intention-to-treat principle, missing values were imputed using the expectation maximization method (Dempster, Laird, & Rubin, 1977). Separate single mediator models were tested for all potential mediators following the procedures described above. A multiple mediator model was tested using the same procedure as noted above, but with all potential mediators included in Stage 2 (i.e., B coefficient).

3. Results

A total of 460 children (199 children in intervention group and 261 in control group) from eight primary schools (25 classes) participated in the SCORES study with the mean age 8.5 ± 0.6 years, 54.1% of the sample was female and 97.6% spoke English at home. Weight status of participants was as follows: underweight ($n = 1$), normal ($n = 65$), overweight ($n = 20$) and obese ($n = 15$). For total physical activity, 54.3% of children provided useable accelerometer data at baseline and 30.0% of children provided useable accelerometer data at post-test (265 did not provide valid data [i.e., did not meet valid accelerometer wear time criteria], 42 children left the schools, 12 children were absent and 3 children withdrew from the study). Children who completed baseline assessment but did not complete post-test assessment did not differ from the remaining children in terms of age, sex and physical activity ($p > 0.05$). A detailed description of the children's characteristics and intervention effects for physical activity have been reported previously (Cohen et al., 2014). In summary, using linear mixed models, at post-test (12-months post baseline), significant group-by-time interaction effects were found for daily MVPA (adjusted mean difference, 12.7 MVPA mins/day; 95% CI, 5.0 to 20.5; $p = 0.008$).

3.1 Effect of intervention on mediators

Mediation results for total physical activity (MVPA minutes) as the outcome are presented in Table 2. Significant intervention effects were observed for social support from teachers ($A = 1.73$, $SE = 0.88$, $p = 0.048$) and parental perceived access to physical activity opportunities in the local community ($A = 2.69$, $SE = 1.12$, $p = 0.016$). There were no significant intervention effects on any of the potential psychological constructs ($p > 0.05$).

3.2 Effect of mediators on physical activity

There was a significant association between changes in perceived sport competence ($B = 0.48$, $SE = 0.36$, $p = 0.027$), parental perceived access to physical activity opportunities in

the local community ($B=0.60$, $SE=0.26$, $p=0.021$) and total MVPA levels. There were no significant effects for any other hypothesized mediators for total MVPA ($p>0.05$).

3.3 Significance test of mediated effect

Parental perceived access to physical activity opportunities in the local community mediated the effect of the intervention on total MVPA ($AB=1.61$, 95% $CI=0.06$ to 3.95 , proportion 13%). No other hypothesized mediators satisfied the criteria for mediation for total MVPA.

3.4 Supplementary analysis

Results are reported in Table 3 and Table 4. There were no significant effects for any hypothesized mediators for total MVPA ($p>0.05$).

4. Discussion

The aim of this study was to examine if individual, social and environmental constructs mediated changes in MVPA in the SCORES intervention. The study demonstrated that the construct relating to the physical environment (i.e., parental perceived access to physical activity opportunities in the local community), mediated the effect of the SCORES intervention on MVPA. No other constructs satisfied the criteria for mediation for MVPA.

Findings from the current study demonstrate that the physical environment construct, parental perceived access to physical activity opportunities in the local community, acted as a causal mechanism explaining change in physical activity behavior among children. Few studies have examined the mediating effects of physical activity opportunities in the local community on physical activity behaviors (Lubans et al., 2008b; van Stralen et al., 2011), and to the authors' knowledge this is the first study to be conducted in children. Results from the current study are similar to a previous study conducted in adolescent girls, which found

evidence for the mediation effects of access to community physical activities on objectively measured physical activity (Lytle et al., 2009), reinforcing the importance for community physical activity opportunities for both children and adolescents in promoting physical activity. Parent engagement strategies (newsletters and parent evening) were used to educate parents on and increase parents awareness of areas where children could be active in the local community (e.g., parks with equipment, bike paths, open play spaces and community sport), how to access the facilities (e.g., safe walking routes, contact details for facility use and community sport) and strategies to reduce associated environmental barriers. Options of places in the local community that were free of cost, easily accessible and safe, such as frequently used and well-lit local parks, paths and playgrounds, community physical activities (e.g., parkrun) and community sport centres (e.g. Police Citizens Youth Clubs), were identified to parents, which may be particularly important for populations from low-income communities as often cost and safety are major barriers to participation. Visits from local sporting organisations and clubs were conducted in the intervention schools. These visits aimed to increase awareness of and children's participation in community sport, through exposure and parent information flyers. In addition, sporting organisations that offered low cost registration or discounts for multiple registrations from the one family were invited to participate in the visits, which aimed to decrease the financial barrier of community sport. Our findings demonstrate that including strategies in interventions that educate and expose parents and children on where and how to access physical activity opportunities in the local community is important for children's engagement in physical activity.

To the authors' knowledge this is the first study to investigate the mediating effects of access to physical activity promoting facilities and equipment at home in a school-based physical activity intervention in children. Previous reviews have recommended more studies investigate the mediating effects of the physical environment in successful physical activity

interventions in children (Lubans et al., 2008b; van Stralen et al., 2011). Results from the current study indicate that access to facilities and equipment in the home did not mediate physical activity in the SCORES intervention. Improving access to physical activity promoting facilities and equipment in the home setting was targeted through parental engagement strategies in the SCORES intervention. Information was provided in newsletters and at the parent evening on the benefits of and how to encourage access to and use of existing facilities or equipment in the home to promote physical activity in their children. However, improving children's access to facilities and equipment in the home setting may be a challenging construct to modify in low-income communities. Financial restraints may prevent the modification or addition of facilities and equipment that encourage children to be physically active, as other priorities such as food and household bills take preference. It is plausible that the inclusion of intervention strategies such as the provision of sporting equipment packs to each family or creating a school sports library borrowing system may reduce the financial barriers of this construct. Future research is needed to further investigate the mediating role of access to facilities and equipment at home and associated intervention strategies to promoting physical activity in children.

Few studies have investigated the mediating effects of enjoyment or perceived competence among children. Findings from the current study are consistent with previous studies in children, which found that enjoyment does not mediate intervention effects on physical activity (Eather et al., 2013) or outdoor play frequency (van Stralen et al., 2012). Although a number of strategies were implemented in the SCORES intervention to increase children's enjoyment of physical activity, the relatively high baseline enjoyment scores (mean 4.2/5.0), similar to those observed in previous interventions (Eather et al., 2013), suggest that children already enjoyed participating in physical activity. It is plausible that the null findings are due to a ceiling effect, as children's enjoyment had only a small scope for

improvement. Moreover, the limited mediation effects could be a result of children reporting elevated levels of perceived competence. At this age, children may not have the cognitive capacity to accurately assess their physical abilities. Further, perceived competence may be a more relevant mediator for physical activity during adolescence when youth become more aware of their physical attributes and disengage from physical activity (Babic et al., 2014; Nader, Bradley, Houts, McRitchie, & O'Brien, 2008; Stodden et al., 2008). Although perceived competence did not mediate physical activity in the current study, changes in perceived competence were significantly associated with changes in physical activity. This is an important finding as it provides evidence that perceived competence may play a role in physical activity promotion in this population. More high-quality studies are required to investigate the role of enjoyment and perceived competence as mediators for physical activity and if/how this may be moderated by age and gender.

Teachers play a key role in promoting physical activity in the school setting through quality learning experiences and providing a school social environment that is supportive of being physically active (McLeroy et al., 1988; Sallis, Prochaska, & Taylor, 2000; Whitehead & Corbin, 1997). Importantly, the SCORES intervention had a significant effect on teacher social support, which gives promise to the strategies that were used in the intervention to increase students' physical activity. However, teacher social support did not mediate physical activity in the current study. These results concur with a recent systematic review which found moderate evidence for a lack of mediation effects for social support from teachers (van Stralen et al., 2011). In contrast, a recent Australian study found that social support from teachers mediated physical activity behavior change in children participating in the Fit-4-Fun intervention, suggesting further work in this area is warranted (Eather et al., 2013). The null findings for social support in the current study may be due to the high turnover of teachers in the intervention schools, which is often observed in schools from low-income communities

(Bauer, Patel, Prokop, & Austin, 2006; Foreman, 2009). Further, although professional learning was provided to the new teachers, they may have needed more time to develop the skills and confidence necessary to provide social support for physical activity to their students.

Investigation of peer social support as a mediator in physical activity interventions in children is limited. Results in the current study are consistent with the limited studies, which found little evidence of peer social support as a causal mechanism in physical activity interventions (Eather et al., 2013; van Stralen et al., 2012; van Stralen et al., 2011). While the SCORES student leadership strategy appeared to be successful at providing students with more opportunities to be active during break-time through the increased availability of equipment and organised activities, the student leadership program was not sufficient to influence students' perceptions of the social support received from their peers. Previous studies have used similar strategies to increase peer social support with reported challenges of adherence (Eather et al., 2013) and the possibility of this strategy causing increased awareness of peer social support or lack thereof, impacting on post-test data (Lubans, Morgan, & Callister, 2012). Further investigation into effective strategies to increase students' perceptions of peer social support in the primary school setting is needed.

Social support from family didn't mediate physical activity in the current study. This is surprising considering the significant role that family members, in particular parents, can play in promoting health behaviors through modelling, providing encouragement and facilitating environments conducive of physical activity. Findings from the current study are consistent with previous school-based physical activity interventions which found limited evidence for the mediating effects of family social support on physical activity (Eather et al., 2013; van Stralen et al., 2011). The limited finding in previous studies could be attributed to the challenge of engaging family members in physical activity programs (O'Connor, Jago, &

Baranowski, 2009). A number of strategies were implemented to improve the social support from family in the SCORES intervention (i.e., newsletters, parent evening and fundamental movement skill homework). While our process evaluation results indicate that children generally completed fundamental movement skill homework once per week and parents reported that the newsletters provided them with useful information about the promotion of physical activity, attendance at the parent evening was quite low (Cohen et al., 2014). The parent evening was a key strategy used to educate the parents on the importance of and how to provide supportive environments for their child to be active. Further investigation on how to effectively engage parents, particularly among those from low-income communities is needed.

Confirmation of the hypothesized mediating mechanisms can prompt developers of future interventions to strengthen or add intervention components targeting these specific mediators. However, findings of limited mediation effects are also important for systematic progression of physical activity research as it will assist in understanding the relevance of hypothesized mediators and the effectiveness of the intervention strategies used. It is important to note that the SCORES intervention was guided by socio-ecological theory and was designed to target students, teachers, parents and the school environment. Our failure to impact upon the hypothesized mechanisms of behavior change, particularly those individual level constructs, is consistent with previous school-based physical activity interventions and may reflect high baseline levels and lack of measurement sensitivity (D. R. Lubans, C. Foster, & S. J. Biddle, 2008a). As the constructs operationalized in the current study have been shown to be associated with physical activity behavior in children they have the potential to be relevant mediators if paired with effective intervention strategies. Moreover, further investigation of the identified potential mediators is needed to confirm if these are or

are not relevant mediators for physical activity behavior in children, or are more appropriate mediators for different age groups, such as adolescence.

A multiple mediator model analysis could not be conducted with the ‘completers’ data due to inadequate power. Therefore a supplementary analysis involving a multiple mediator model analysis with intention-to-treat data was conducted. Results from this analysis revealed that no hypothesized mediators emerged as significant. Although intention-to-treat analysis is considered the most appropriate method for evaluating interventions, this paper was focused on examining the potential mechanisms of behavior change. Intention-to-treat analysis involves the imputation of missing data or the estimation of missing data using mixed models. We decided that using a ‘completers’ analysis was superior to the imputation of large amounts of missing data.

4.1 Strengths and limitations

To the authors’ knowledge this is the first study to investigate the mediating effects of the physical environment (i.e., parental perceived access to physical activity opportunities in the local community and physical activity facilities and equipment at home) in a successful school-based physical activity intervention in children. The innovative multi-component intervention design that was evaluated using a cluster RCT and the objective assessment of physical activity are additional study strengths. However, there are some limitations that should be noted. Although a number of approaches were implemented to improve accelerometer compliance (e.g., text messages and prizes for wearing and returning accelerometers), a low number of children supplied useable accelerometer data at baseline (54.3%) and post-test (30.0%). Assessing change in physical activity behaviors through the use of objective measures, such as accelerometers, is considered best practice, however, compliance to wear time protocol appears to be a consistent challenge for physical activity

researchers (Dollman et al., 2009). Children from low-income communities often demonstrate low levels of adherence to monitoring protocols and providing reliable accelerometer data (Rich et al., 2013). Compliance levels in the current study appear to be consistent with other studies investigating population groups from low-income communities (Rich et al., 2013). Moreover, the disparity in wear time criteria in the literature can also impact on compliance rates. The use of a reduced inclusion criteria (i.e., any three days), or measuring only weekday or school time (Monday to Friday 9:00am-3:00pm) physical activity tend to achieve increased rates of compliance. However, the use of a reduced criteria may not provide a thorough account of the participants' 'usual' weekly physical activity behaviors. Poor compliance to accelerometer monitoring protocols has emerged as a threat to the validity in physical activity intervention studies (Borde, Smith, Sutherland, Nathan, & Lubans, in press; Howie & Straker, 2016). In an attempt to increase compliance in young people, there has been a shift toward reducing the number of required days and adopting 24hour/day accelerometer wear-time protocols (Wolff-Hughes, McClain, Dodd, Berrigan, & Troiano, 2016). In addition, more studies are now using wrist worn accelerometers, which appear to be more acceptable among children and adolescents (Fairclough et al., 2015). Finally, the low internal consistency of some measures (social support from peers, access to facilities at home) may partially explain why some study hypotheses were not fully supported.

5. Conclusions

Findings from the current study add to the limited body of evidence examining mediators of behavior in physical activity interventions among children. Although the intervention successfully increased children's objectively measured physical activity, aerobic fitness and movement skill proficiency, there were no significant effects for any of the potential social or psychological constructs. Alternatively, the intervention effect was

mediated by changes in the physical environment, specifically parental perceived access to physical activity opportunities in the local community. This provides evidence for recommending the inclusion of components to increase both parental and child perceived access to physical activity opportunities in the local community as a mechanism of behavior change, and thus, a strategy that should be included in interventions aimed at increasing children physical activity.

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Figure 1 Mediation model showing the hypothesized mediators of the effect of the SCORES intervention on physical activity.

703

704

Table 1 Hypothesized mediators, intervention strategies and scale descriptions

Hypothesized mediators	Intervention strategies	Description of scale	Range	Source	α (baseline)
			No. of items		α (post-test)
Enjoyment	<ul style="list-style-type: none"> <i>Professional learning workshops for teachers</i> - Teachers were trained to deliver PE lessons using the ‘SAAFE’ teaching principles (Supportive, Active, Autonomous, Fair and Enjoyable). 	Children were asked to respond to a relevant feeling about physical activity and select how much they disagree or agree with the statement.	1-5	Physical Activity Enjoyment Scale (PACES) [28]	0.79
		Example item: “ <i>When I am active...I enjoy it</i> ” Scale: 1=Disagree a lot to 5=Agree a lot	9 items		0.90
Perceived sport competence	<ul style="list-style-type: none"> <i>Professional learning workshops for teachers</i> - Teachers were trained to deliver PE lessons using the ‘SAAFE’ teaching principles (Supportive, Active, Autonomous, Fair and Enjoyable). Teachers were trained to provide quality learning experiences to develop children’s fundamental movement skill competency. 	Children had to decide which of the two statements about physical activity best describes them and then choose whether the statement is ‘sort of true’ or ‘really true’ for them.	1-4	Perceived competence sub-scale from Harter’s Self-Perception Profile (SPP) [29]	0.69
		Example item: “ <i>Some kids wish they could be a lot better at sports BUT Other kids feel they are good enough at sports</i> ” Scale: 1=Really true for me, 2=Sort of true for me, 3=Sort of true for me, 4=Really true for me (1=low perceived sport competence, 4=high perceived sport competence).	6 items		0.76
Social support from family	<ul style="list-style-type: none"> <i>Newsletters and Parent evening</i> – Educate parents on the importance of and strategies for providing supportive environments for their child to be active. <i>FMS homework</i> – Students were encouraged to complete practical homework tasks with their parents. 	Children were asked to select how often a member of their family provided a specific form of social support during a typical week.	1-5	Scale developed for the Amherst Health and Activity Study (Sallis et al., 2002)	0.85
		Example item: “ <i>Encouraged you to do physical activities or play sports</i> ” Scale: 1=Never to 5=Everyday	5 item		0.78

		Parents of children in the study were asked to select how often significant people in the family provided support for their child's participation in physical activity and praised their child for participating in physical activity.	1-6 8 item	Children's Leisure Activities Study Survey (CLASS) (Telford et al., 2004)	0.79 0.77
		Example item: " <i>Father/male carer</i> "			
		Scale: 1=Never to 6=Daily			
Social support from teachers	<ul style="list-style-type: none"> <i>Professional learning workshops for teachers</i> - Teachers were trained to deliver PE lessons using the 'SAAFE' teaching principles (Supportive, Active, Autonomous, Fair and Enjoyable). 	Children were asked to select how often their teacher provided a specific form of social support.	1-5 5 item	Existing scale developed for a previous study (Lubans et al., 2011)	0.75 0.76
		Example item: " <i>During PE and school sport my teacher appears enthusiastic about the activity</i> "			
		Scale: 1=Never to 5=Always			
Social support from peers	<ul style="list-style-type: none"> <i>Student leadership</i> - Students were trained to be physical activity leaders in their school where they would encourage their peers to be physically active during break-times (recess and lunchtime) and PE through completing a number of set up, run and promote tasks. 	Children were asked to select how often during a typical week their peers provided a specific form of social support.	1-5 5 item	Scale developed for the Amherst Health and Activity Study (Sallis et al., 2002)	0.65 0.67
		Example item: " <i>Do your friends encourage you to do physical activities or play sports</i> "			
		Scale: 1=Never to 5=Always			
Access to facilities at home	<ul style="list-style-type: none"> <i>Newsletters and Parent evening</i> – Educate parents on the benefits of and strategies to encourage access to and use of existing facilities and equipment in the home to promote physical activity in their children. 	Parents of children in the study were asked to select which facilities their family had in their home/yard.	1-2 11 item	CLASS (Telford et al., 2004)	0.60 0.49
		Example item: " <i>Sandpits/swings/play equipment</i> "			
		Scale: 1=No to 2=Yes			
Access to equipment at home		Parents of children in the study were asked to select how often their child accessed equipment at home.	1-7 9 item	CLASS [23]	0.70 0.71

		Example item: “ <i>Bats/rackets</i> ”			
		Scale: 1=Don’t have to 7=Daily			
Parental perceived access to physical activity opportunities in the local community	<ul style="list-style-type: none"> • <i>Newsletters and Parent evening</i> – Educate parents on areas where children could be active in the local community, how to access the facilities and strategies to reduce associated environmental barriers. • <i>Community links</i> – School visits from local sporting organisations and clubs which aimed to increase students and parents awareness of and participation in community sport. 	Parent of children in the study were asked to select how much they agreed or disagreed with the following statements regarding physical activity opportunities in their local community.	1-5	CLASS [23]	0.79
			14 items		0.79
		Example item: “ <i>There are few sporting venues within our local area</i> ” Scale: 1=Strongly agree to 5=Strongly disagree			

Note: α = Cronbach’s alpha derived from study sample

Table 2 Action theory test, conceptual theory test and significance of the mediated effect on total physical activity (MVPA minutes) at post-test (12-months)

Hypothesized mediators	n	Treatment on physical activity C' (SE)	Treatment on mediator A (SE)	p value	Mediator on physical activity B (SE)	p value	Significance of mediated effect AB	95% CI	Proportion (%) AB/(C' + AB)
Psychological									
Enjoyment	101	9.59 (2.77)	0.92 (1.46)	0.530	0.18 (0.23)	0.440	0.17	-0.67 to 1.35	2%
Perceived competence	101	9.29 (2.23)	0.06 (0.69)	0.934	0.48 (0.36)	0.027*	0.03	-0.84 to 0.95	<1%
Social Environment									
Social support from family (student report)	100	10.52 (2.34)	0.82 (1.01)	0.416	0.28 (0.28)	0.315	0.23	-0.52 to 1.38	2%
Social support from family (parent report)	81	11.78 (2.77)	0.60 (1.22)	0.623	-0.12 (0.44)	0.783	-0.07	-1.51 to 1.17	1%
Social support from teachers	101	11.31 (2.42)	1.73 (0.88)	0.048*	0.23 (0.42)	0.583	0.40	-1.16 to 2.32	3%
Social support from peers	100	9.70 (2.29)	0.83 (0.67)	0.214	0.02 (0.35)	0.951	0.02	-0.78 to 0.84	<1%
Physical Environment									
Access to facilities at home	84	11.60 (2.83)	0.47 (0.95)	0.621	-0.21 (0.38)	0.584	-0.10	-1.19 to 0.74	1%
Access to equipment at home	82	10.97 (2.77)	1.43 (2.86)	0.616	0.23 (0.20)	0.253	0.33	-1.33 to 2.55	3%
Parental perceived access to physical activity opportunities in the local community	80	10.40 (3.72)	2.69 (1.12)	0.016*	0.60 (0.26)	0.021*	1.61	0.06 to 3.95	13%

Note. C', unstandardized regression coefficient of the intervention predicting physical activity behavior accounting for effect of the mediator; A, unstandardized regression coefficient of treatment condition predicting change in hypothesized mediators; B, unstandardized regression coefficient of change in hypothesized mediators predicting change in physical activity behavior; AB, product-of-coefficients estimate; SE, standard error; 95% CI, 95% confidence interval; *, significant (p<0.05).

Table 3 Intention-to-treat analysis: Action theory test, conceptual theory test and significance of the mediated effect on total physical activity (MVPA minutes) at post-test (12-months)

Hypothesized mediators	n	Treatment on physical activity C' (SE)	Treatment on mediator A (SE)	p value	Mediator on physical activity B (SE)	p value	Significance of mediated effect AB	95% CI	Proportion (%) AB/(C' + AB)
Psychological									
Enjoyment	287	4.73 (2.38)	0.64 (1.21)	0.595	0.13 (0.08)	0.099	0.08	-0.27 to 0.53	2%
Perceived competence	287	4.04 (2.27)	0.35 (0.48)	0.464	0.61 (0.17)	<0.001	0.21	-0.37 to 0.88	5%
Social Environment									
Social support from family (student report)	287	5.32 (2.47)	0.60 (0.45)	0.187	-0.16 (0.17)	0.358	-0.10	-0.46 to 0.13	2%
Social support from family (parent report)	287	5.16 (2.40)	0.25 (0.75)	0.740	-0.05 (0.08)	0.559	-0.01	-0.19 to 0.13	<1%
Social support from teachers	287	5.66 (2.39)	0.92 (0.74)	0.216	0.10 (0.22)	0.656	0.09	-0.41 to 0.74	2%
Social support from peers	287	4.63 (2.29)	1.14 (0.53)	0.031	0.09 (0.18)	0.611	0.10	-0.33 to 0.62	2%
Physical Environment									
Access to facilities at home	287	5.23 (2.35)	0.04 (0.90)	0.967	0.37 (0.19)	0.048	0.02	-0.77 to 0.81	<1%
Access to equipment at home	287	4.83 (2.40)	1.49 (0.92)	0.106	0.18 (0.11)	0.111	0.27	-0.10 to 0.88	5%
Parental perceived access to physical activity opportunities in the local community	287	4.44 (2.42)	0.29 (0.64)	0.998	0.42 (0.11)	<0.001	0.12	-0.42 to 0.71	3%

Note. C', unstandardized regression coefficient of the intervention predicting physical activity behavior accounting for effect of the mediator; A, unstandardized regression coefficient of treatment condition predicting change in hypothesized mediators; B, unstandardized regression coefficient of change in hypothesized mediators predicting change in physical activity behavior; AB, product-of-coefficients estimate; SE, standard error; 95% CI, 95% confidence interval.

Table 4 Multiple mediator model results: Action theory test, conceptual theory test and significance of the mediated effect on total physical activity (MVPA minutes) at post-test (12-months)

Hypothesized mediators	n	Treatment on physical activity C' (SE)	Treatment on mediator A (SE)	p value	Mediator on physical activity B (SE)	p value	Significance of mediated effect AB	95% CI	Proportion (%) AB/(C' + AB)
Psychological									
Enjoyment	287	3.91 (2.37)	0.64 (1.21)	0.595	-0.28 (0.13)	0.029	-0.19	-1.04 to 0.54	5%
Perceived competence	287	3.91 (2.37)	0.35 (0.48)	0.464	0.92 (0.20)	<0.001	0.32	-0.55 to 1.27	8%
Social Environment									
Social support from family (student report)	287	3.91 (2.37)	0.60 (0.45)	0.187	-0.33 (0.19)	0.089	-0.20	-0.69 to 0.11	5%
Social support from family (parent report)	287	3.91 (2.37)	0.25 (0.75)	0.740	-0.21 (0.07)	0.004	-0.05	-0.41 to 0.28	1%
Social support from teachers	287	3.91 (2.37)	0.92 (0.74)	0.216	0.18 (0.23)	0.423	0.17	-0.33 to 0.91	4%
Social support from peers	287	3.91 (2.37)	1.14 (0.53)	0.031	-0.04 (0.18)	0.817	-0.05	-0.54 to 0.41	1%
Physical Environment									
Access to facilities at home	287	3.91 (2.37)	0.04 (0.90)	0.967	0.24 (0.19)	0.196	0.01	-0.58 to 0.61	<1%
Access to equipment at home	287	3.91 (2.37)	1.49 (0.92)	0.106	0.18 (0.09)	0.054	0.27	-0.07 to 0.81	6%
Parental perceived access to physical activity opportunities in the local community	287	3.91 (2.37)	0.29 (0.64)	0.998	0.45 (0.11)	<0.001	0.13	-0.45 to 0.75	3%

Note. C', unstandardized regression coefficient of the intervention predicting physical activity behavior accounting for effect of the mediator; A, unstandardized regression coefficient of treatment condition predicting change in hypothesized mediators; B, unstandardized regression coefficient of change in hypothesized mediators predicting change in physical activity behavior; AB, product-of-coefficients estimate; SE, standard error; 95% CI, 95% confidence interval.