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Title: Physical Activity and Skills Intervention: SCORES Cluster Randomized Controlled Trial

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ABSTRACT

Purpose: Physical activity declines dramatically during adolescence and activity levels are consistently lower among children living in low-income communities. Competency in a range of fundamental movement skills (FMS) may serve as a protective factor against the decline in physical activity typically observed during adolescence. The purpose of this study was to evaluate the impact of a 12-month multi-component physical activity and FMS intervention for children attending primary schools in low-income communities.

Methods: The Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES) intervention was evaluated using a cluster randomized controlled trial. The sample included 25 classes from 8 primary schools located in low-income communities. Participants were 460 children (54.1% girls) aged 8.5 ± 0.6 years. Primary outcomes were objectively measured physical activity (ActiGraph GT3X and GT3X+ accelerometers), FMS competency (TGMD-2; 6 locomotor and 6 object-control skills), and cardiorespiratory fitness (20 meter multistage fitness test) assessed at baseline, mid-program (6-months) and posttest (12-months). Linear mixed models, adjusted for sex, age, BMI-z score, socio-economic status, ethnicity and school class as a random factor, were used to assess the impact of the intervention.

Results: At mid-program, there were no significant intervention effects for any of the outcomes. At posttest, (study's primary time point), there were intervention effects for daily moderate-to-vigorous physical activity (MVPA) (adjusted mean difference, 12.7 MVPA mins/day; 95% CI, 5.0 to 20.5), overall FMS competency (4.9 units; 95% CI, -0.04 to 9.8), and cardiorespiratory fitness (5.4 laps; 95% CI, 2.3 to 8.6).

Conclusions: A school-based multi-component physical activity and FMS intervention maintained daily MVPA, improved overall FMS competency and increased cardiorespiratory fitness among children attending primary schools in low-income communities.

50   **Trial registration:** Australian New Zealand Clinical Trials Registry No:

51   ACTRN12611001080910

52   **Key words:** low-income; children; primary school; cardiorespiratory fitness; fundamental

53   movement skills; socio-ecological

54

INTRODUCTION

Paragraph Number 1 Physical inactivity has been described as a global pandemic(18).

Global estimates suggest that 80% of young people are not participating in adequate amounts of moderate-to-vigorous physical activity (MVPA) to acquire the associated physical, social, cognitive and psychological benefits(18). Schools have been identified as important settings for the promotion of physical activity among children(8), as they have the necessary resources and provide access to populations at risk of being physically inactive, such as those from low socio-economic backgrounds(13, 20).

Paragraph Number 2 Numerous school-based interventions have been evaluated and evidence suggests that multi-component interventions are more effective than curriculum only approaches(22). Although strong evidence exists for the effectiveness of school-based physical activity interventions(1, 5) it is rare that studies report their effect on fundamental movement skill (FMS) competency. This is a notable exclusion, as evidence suggests that competency in a range of FMS may serve as a protective factor against the decline in physical activity typically observed during adolescence(4).

Paragraph Number 3 FMS are considered the building blocks for movement and the primary school years are the optimal stage of life to develop proficiency(17). For most, FMS competency does not occur naturally and is more likely to be achieved through quality instruction and active play experiences(17). FMS can be categorized as locomotor (e.g., run, hop, jump, leap), object-control (e.g., throw, catch, kick, strike), and stability (e.g., static balance) skills(17). Strong evidence exists for a positive association between FMS and physical activity, and FMS and cardiorespiratory fitness in children, and an inverse association between skill level and weight status in children(27). Although the health benefits gained from developing FMS competency in children is clear(27), competency among children is low(15, 19).

Paragraph Number 4 Socio-environmental factors (e.g., reduced access to physical activity facilities and resources, working parents and unsafe neighborhoods)(12, 43) and ineffective school-based strategies, including poor quality physical education (PE)(11), may explain the low physical activity levels and poor FMS competency among children living in low socio-economic communities. These findings highlight the need to evaluate school-based approaches to promote physical activity among those most at risk of being physically inactive (i.e., those from low socio-economic backgrounds). The aim of the current study was to evaluate the effects of the Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES) program(28), a 12-month school-based cluster randomized controlled trial, designed to increase physical activity and improve FMS competency among children attending primary schools in low-income communities. This study reports the mid-program (6-month) and posttest (12-month; study's primary time point) intervention effects.

METHODS

Study design and participants

Paragraph Number 5 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 and study participants provided written informed consent. The design and methods of the SCORES cluster randomized controlled trial (RCT) have been reported in detail elsewhere(28). The design, conduct, and reporting of this cluster RCT adhered to the Consolidated Standards of Reporting Trials (CONSORT) guidelines for group trials(7). Baseline assessments were conducted in February through March 2012, mid-program (6-month post baseline) assessments in August through September 2012, and immediate posttest (12-month post baseline; study's primary time-point) assessments were completed in February through March 2013.

Paragraph Number 6 The intervention was designed for children from schools located in low-income communities, and the Socio-Economic Indexes for Areas (SEIFA) index of relative socioeconomic disadvantage(3) were used to identify eligible primary schools. The SEIFA index (scale 1 = lowest to 10 = highest) summarizes the characteristics of people and households within an area and was developed using the following data: employment, education, financial wellbeing, housing stress, overcrowding, home ownership, family support, family breakdown, family type, lack of wealth (no car or telephone), low income, Indigenous status and foreign birth(3). Sixteen government primary schools located within 30km radius from the University of Newcastle with a SEIFA index of ≤ 5 (lowest 50%) were invited to participate in the study and eight schools (25 classes) consented to participate (50% consent rate). All students in grades 3 and 4 (Stage 2; aged 7 to 10 years) at the study schools were invited to participate in the program. From the 592 eligible children at the eight schools, 460 children consented to participate (78% consent rate).

Sample size calculation and randomization

Paragraph Number 7 Power calculations were conducted to determine the sample size required to detect changes in the three primary outcomes [i.e., physical activity, FMS and cardiorespiratory fitness] at the posttest (12-month post baseline; study's primary time point) assessments. All calculations assumed baseline-posttest correlation scores of 0.80 and were based on 80% power with alpha levels set at $p < 0.05$. Using the standard deviation (SD = 33) and intraclass correlation coefficient (ICC = 0.05) values from the Kinder-Sportstudie (KISS)(23), it was calculated that a study sample of N= 440, with 8 clusters (i.e. schools) of 55 students would provide adequate power to detect an achievable between group difference of 11 moderate-to-vigorous physical activity (MVPA) minutes/day(23). Based on data from the Action Schools BC! (SD = 13)(35) and the KISS (ICC = 0.03)(23) studies, a sample of 440 would also provide adequate power to detect a between group difference of 4 laps on the

multi-stage fitness test (i.e., cardiorespiratory fitness outcome). In the absence of existing ICC values for FMS outcomes, an ICC estimate of 0.05 and a SD of 15 units(42) indicated that the study would be adequately powered to detect a between group difference of 5 units on the Test of Gross Motor Development – 2 (TGMD-2).

Paragraph Number 8 Following baseline assessments, the 8 schools were match-paired (i.e., 4 pairs of schools) based on their size and socio-economic position (based on post-code of school). These pair-matched schools were then randomized to control or intervention conditions by an independent researcher using a computer-based random number producing algorithm. The schools were allocated to either the SCORES intervention or control group for the duration of the study. Assessors were blinded to treatment allocation at baseline but not at follow-up assessments.

Intervention

Paragraph Number 9 SCORES was a 12-month multi-component physical activity and FMS intervention for primary schools in low-income communities. A detailed description of the SCORES intervention has been reported previously(28). Briefly, the socio-ecological model(30) provided a framework for the intervention components. The SCORES intervention was implemented in three phases. Phase 1 (implemented from April 2012) focused on teacher professional learning, student leadership workshops and physical activity promotion tasks to achieve awards. Students who completed 5 tasks achieved a SCORES Yellow Leader Award, 10 tasks achieved a SCORES Red Leader Award and 15 tasks achieved a SCORES Blue Leader Award. Examples of tasks included: acting as equipment monitor, organizing games at recess and lunch, and writing physical activity promotion article for the school newsletter. Equipment was also provided to school during this phase and the school committee was established. In Phase 2 (implemented from July 2012), intervention schools were encouraged to implement six physical activity policies in order to support the promotion of physical

activity and FMS competency within the school. A member of the research team met with the principal at the intervention schools to explain the policies. The member of the research team then conducted a meeting with all staff members to explain the policies and provide strategies for implementation of the policies. In addition, the research team employed a range of strategies targeting the home environment (newsletters, parent evening, and FMS homework) to engage parents and encourage them to support their children's physical activity. Phase 3 (implemented from October 2012) addressed strategies to improve school-community links (e.g., inviting local sporting organizations to assist with school sport programs).

Paragraph Number 10 The control schools were asked to follow their usual PE and school sport program. The NSW Department of Education and Communities requires by policy that all schools provide students with 120 minutes of planned physical activity per week. In government primary schools, sport programs are similar among schools. All schools in the study did not have PE specialists. PE and sport were taught by the generalist classroom teacher. To assist in recruitment of schools and prevent resentful demoralization or compensatory rivalry(34), the control schools were provided with equipment packs and a condensed version of the program following the posttest (12-month) assessments.

Assessments and measures

Paragraph Number 11 Data collection was conducted at the study schools by trained research assistants. For consistency and accuracy, a protocol manual, which included specific instructions for conducting all assessments, was developed and used by research assistants to standardize procedures and for quality assurance. The same research assistants were used across all three time-points. Assessors were blinded to treatment allocation at baseline but not at follow-up assessments.

Primary outcome measures

Physical activity

Paragraph Number 12 Physical activity was assessed using triaxial ActiGraph GT3X+ accelerometers (ActiGraph, LLC, Fort Walton Beach, FL). Accelerometers were worn by participants during waking hours for seven consecutive days, except while bathing and swimming. Trained research assistants, following standardized accelerometer protocols (41), fitted the monitors and explained the monitoring procedures to students. MeterPlus version 4.3 software (Santech Inc., San Diego, US) was used to analyze accelerometer data. 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. Valid wear time for within school and after-school physical activity was defined as a minimum of three weekdays with at least eight hours (480 minutes/day) of total wear time recorded. The within school time period was defined as the period time from when school started for each participant (ranged from 9:00 am – 9:15 am) to the time when school ended for each participant (3:00 pm for all participants). The after-school time period was defined as the period of time from when school ended for each participant (3.00 pm for all participants) to 6.00 pm. Valid wear time for weekend physical activity was defined as a minimum of one 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(6, 38). The mean activity counts per minute (CPM) were calculated, 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, and minutes and percentage spent in each activity intensity(16).

Fundamental movement skills (FMS)

Paragraph Number 13 FMS competency was assessed using the TGMD-2(42) which has established validity and reliability in children(42). The TGMD-2 includes six locomotor (i.e.,

run, gallop, hop, leap, horizontal jump, slide) and six object control (i.e., striking a stationary ball, stationary dribble, kick, catch, overhand throw, and underhand roll) skills. Participants performed each skill twice and skills were video-taped for assessment. Each skill includes several behavioral components. If the participant performed a behavioral component correctly they received a score of 1; if they performed it incorrectly they received a 0. This procedure was completed for each of the two trials, and scores were summed to obtain a total raw skill score. The raw skill scores were then added to obtain a raw locomotor subtest score and a raw object-control subtest score. The raw locomotor subtest score and the raw object-control subtest score were then added to obtain a raw overall FMS score(42). Inter-rater reliability (98% agreement rate) and intra-rater reliability (97% to 99% agreement rate) were established using pre-coded video tapes before movement skills were assessed by three assessors. Kappa values were also calculated to take into account agreement beyond chance. These were 0.97 (95% CI, 0.96 to 0.98) for inter-rater reliability and ranged from 0.94 (95% CI, 0.91 to 0.97) to 0.98 (95% CI, 0.97 to 0.99) for intra-rater reliability.

Cardiorespiratory fitness

Paragraph Number 14 Cardiorespiratory fitness was assessed using the 20 meter multistage fitness test(24). Participants were required to run back and forth between two lines over a 20 m distance within a set time limit. Running speed started at 8.5 km/hour and increased by 0.5 km/hr each minute using the multistage test cadence CD. Participants were instructed to run in a straight line and to place one foot over the 20 m line before the next beep. The test was completed when a participant failed to reach the line for two consecutive shuttles. Scores were recorded as the level and shuttle reached, which was converted to the number of 20 m laps completed to provide a continuous variable for analysis.

Height and weight

229 **Paragraph Number 15** Height was recorded to the nearest 0.1 cm using a portable
230 stadiometer (Model no. PE087, Mentone Educational Centre, Australia). Weight was
231 measured in light clothing without shoes using a portable digital scale (Model no. UC-321PC,
232 A&D Company Ltd, Tokyo Japan) to the nearest 0.1 kg. Body mass index (BMI) was
233 calculated using the standard equation ($\text{weight}[\text{kg}]/\text{height}[\text{m}]^2$) and BMI-z scores were
234 calculated using the 'LMS' method(10).

235 **Demographic measures**

236 **Paragraph Number 16** Participating children completed a questionnaire to obtain
237 demographic information including sex, age, language spoken at home, Aboriginal or Torres
238 Strait Islander decent, ethnicity and suburb. The suburb of the child's residence was used to
239 determine their socio-economic status (SES) using the SEIFA index of relative
240 socioeconomic disadvantage(3).

241 **Process evaluation**

242 **Paragraph Number 17** A detailed process evaluation was conducted and included i) teacher
243 and student attendance at workshops (i.e., percentage attendance), ii) student leadership
244 accreditation (i.e., number of students who complete the workshop and satisfied the
245 accreditation guidelines), iii) teacher satisfaction with professional learning workshops (using
246 workshop evaluation questionnaires at the end of Phase 1), iv) parental involvement was
247 determined using a process evaluation questionnaire completed by parents (e.g. reading
248 newsletters and completion of home-based FMS tasks) and attendance at the parent evening,
249 v) teacher, student and parent satisfaction with all intervention components (using process
250 evaluation questionnaires at the completion of the study), vi) compliance with PA policies
251 was determined through interviews with school Principals (one interview at each of the four
252 intervention schools was conducted. On average, the interviews lasted one hour), and vii) PE
253 intervention fidelity was determined using the SCORES lesson observation checklist. The

checklist assessed teachers adherence to the recommended PE lesson structure and included the following components with a 'Yes' (= 1) or 'No' (= 0) response: 1) Introduction: i) Teacher reviews previous lesson, ii) Teacher explains lesson focus, 2) Warm up: i) Lesson involves general movement-based warm-up and ii) Warm-up includes dynamic and/or static stretching, 3) Skill development: i) Teacher or student demonstrates the skill and ii) Lesson involves skill exploration, iii) Lesson involves guided discovery, 4) Skill application: i) Lesson involves modified games and ii) Lesson involves full-sided games and 5) Closure: i) Lesson includes cool down, ii) Teacher uses questioning to check for student understanding and iii) Teacher reinforces key skill components, and if the teacher was using the SCORES teaching resource. At the intervention schools, stage 2 teachers' PE lessons were observed three times by a member of the research team. The results of the observations were provided to the teachers immediately following each observation.

Statistical analyses

Paragraph Number 18 All analyses were performed using IBM SPSS Statistics for Windows, Version 20 (2011 SPSS Inc., IBM Corp., Armonk, NY) and statistical significance was set at $P < 0.05$. Data were assessed for normality of distribution and transformed where necessary. Differences between groups at baseline for those who did not complete follow-up assessments were examined using independent sample t tests and chi-squared (χ^2) tests for categorical variables. Statistical analyses followed the intention-to-treat principle and were conducted using linear mixed models, which have the advantage of being robust to the biases of missing data(29). Mixed models were used to assess all outcomes for the impact of treatment (Intervention or Control), time (treated as categorical with levels baseline, 6-months and 12-months) and the group-by-time interaction, these three terms forming the base model. Sex, age, BMI-z score, SES and ethnicity were included as fixed factors; and school class as a random effect. School class was the smallest cluster in the sampling design;

therefore it was introduced as a random effect(23). Intraclass correlation was calculated to compare the variation between school classes as a fraction of the total variance.

RESULTS

Paragraph Number 19 Twenty-five classes in eight schools including 460 children (199 children in intervention group and 261 in control group) entered the study (Figure 1). Table 1 shows the baseline characteristics by treatment group. Tables 2 and 3 describe results for primary outcomes at baseline, mid-program (6-months), and posttest (12-month). Children with a baseline assessment but no posttest assessment did not differ from the remaining children in terms of sex ($\chi^2 [1] = 3.09, P=0.079$), age ($t [246] = 1.49, P=0.137$), physical activity ($t [246] = 0.08, P=0.939$), object-control skills ($t [452] = -0.82, P=0.410$) or cardiorespiratory fitness ($t [435] = -0.86, P=0.392$). However, children who did not complete posttest assessment had lower locomotor skill competency (mean [SD], 23.8 [5.7] vs 26.0 [5.7]; $t [426] = -3.06, P=0.002$) compared to those who completed posttest assessments.

Primary outcomes at mid-program (6-months post baseline)

Paragraph Number 20 Table 2 shows the results of the primary outcomes at baseline and mid-program, as well as the adjusted differences at mid-program. There were no statistically significant group-by-time interactions for physical activity, FMS or cardiorespiratory fitness at mid-program.

Primary outcomes at posttest (12-months post baseline; study's primary time point)

Paragraph Number 21 Table 3 shows the results of the primary outcomes at baseline and posttest, as well as the adjusted differences at posttest (12-month minus baseline). There was a statistically significant group-by-time interaction in favor of the intervention group for daily MVPA minutes ($p=0.008$), corresponding to a difference of 13 minutes of MVPA/day. There was also a statistically significant group-by-time interaction in favor of the intervention group for daily after-school MVPA minutes ($p=0.028$) and daily weekend MVPA minutes

($p=0.034$). The changes in total physical activity ($p=0.054$), MVPA % ($p=0.051$) and within school MVPA ($p=0.182$) from baseline to posttest showed trends in favor of the intervention group. There was a statistically significant group-by-time interaction for overall FMS with children in the intervention group scoring significantly higher ($p=0.045$) than those in the control group. Changes in locomotor and object control skills were in favor of the intervention group, but there were no statistically significant group-by-time interactions. The intervention resulted in a significant group-by-time interaction for children's cardiorespiratory fitness ($p=0.003$), corresponding to an additional 5 laps on the 20m multi-stage fitness test.

Process outcomes

Paragraph Number 22 Nine out of 13 (69.2%) Stage 2 (grade 3 and 4) teachers at the intervention schools (these teachers were the specific target of the intervention) attended the full day professional learning workshop, and 50 out of 57 (87.7%) teachers at the intervention schools (all teachers in the school) attended the whole-school professional learning workshop (a member of the research team met with those teachers who were unable to attend the full day workshop and explained the intervention strategies and components). Overall, Stage 2 teachers were satisfied with the professional learning workshop; they found the workshop enjoyable (mean [SD], 4.9 [0.3]; rating scale, 1 = strongly disagree to 5 = strongly agree) and provided them with useful information about effective teaching of FMS (mean [SD], 4.8 [0.4]; rating scale, 1 = strongly disagree to 5 = strongly agree). Similarly, teachers were satisfied with the whole-school professional learning workshop, reporting that the workshop was enjoyable (mean [SD], 4.7 [0.5]; rating scale, 1 = strongly disagree to 5 = strongly agree) and provided useful information about effective teaching of FMS (mean [SD], 4.6 [0.7]; rating scale, 1 = strongly disagree to 5 = strongly agree). A total of 177 children attended the student leadership workshop (88.5%). 145 out of 177 (81.9%) children achieved the

SCORES Yellow Leader Award, 105 children achieved the SCORES Red Leader Award (59.3%), and 73 children achieved the SCORES Blue Leader Award (41.2%). Overall, children were satisfied with the program (mean [SD], 2.7 [0.6]; rating scale, 1 = not really to 3 = a lot). Parents reported that on average their child completed FMS homework once per week (mean [SD], 3.6 [1.8]; rating scale, 1 = never to 5 = greater than once per week). Parents reported that the newsletters provided them with useful information about the promotion of physical activity in children (mean [SD], 3.8 [0.7]; rating scale, 1 = strongly disagree to 5 = strongly agree). In total, 140 parents attended the parent evenings. 75% of the intervention schools complied with policy 1 (*Functioning school PA committee*), all intervention schools complied with policy 2 (*All students participate in at least 120 minutes of timetabled PE and school sport per week*), 25% of intervention schools complied with policy 3 (*50% of PE and school sport time devoted to MVPA*). The intervention schools were provided with a class set of pedometers. Teachers were encouraged to use the pedometers to measure their students' MVPA during PE and school sport. If the students were achieving 75-85 steps/minute in the lesson it was deemed to be equivalent to 50% MVPA(39)), 25% of intervention schools complied with policy 4 (*Annual reporting of students' FMS and fitness levels*), 75% of intervention schools complied with policy 5 (*Promotion of active playgrounds*), and 25% of intervention schools complied with policy 6 (*Involve family members / carers in school based PA*). Each of the 4 intervention schools had 4 visits from community sporting organizations and 58.7% of children reported that they had joined a local sporting club. On average, Stage 2 teachers at the intervention schools adhered to 62.9% of the recommended PE lesson structure at observation 1, 70.5% at observation 2, and 79.0% at observation 3. No injuries or adverse effects were reported during implementation of the intervention components or assessments.

DISCUSSION

Paragraph Number 23 The SCORES school-based multi-component physical activity and FMS intervention resulted in significant group-by-time interactions for daily MVPA, overall FMS competency and cardiorespiratory fitness among children attending primary schools in low-income communities. Results from the SCORES intervention add to the body of evidence for the effectiveness of multi-component school-based interventions.

Paragraph Number 24 While no significant group-by-time interactions were observed at mid-program, there was a significant increase in MVPA among those in the intervention group. The increase in physical activity observed at mid-program could be attributed to a seasonal effect. In Australia, children participate in more extracurricular sport during the winter months(2), thus increasing physical activity during this time. At posttest, the control group's physical activity significantly decreased while the intervention group maintained their physical activity. A significant group-by-time interaction was observed at posttest indicating that the SCORES intervention was protective against declines in children's physical activity. Following the completion of the intervention, the adjusted difference between intervention and control schools was 13 minutes of MVPA per day. This finding is comparable to the intervention effect observed in the KISS study(23) (11 minutes per day). The KISS study involved the addition of daily PE lessons delivered by specialists, which may not be feasible in many schools due to the pressures of a crowded curriculum and the cost of employing specialists(33). In contrast, the SCORES intervention was able to achieve an intervention effect for children's daily MVPA without increasing the time allocated to PE or school sport, or taking time away from other subjects, which is important for possible future adoption in schools. The SCORES intervention effects add to the body of evidence identified in a recent systematic review(31), which found that, on average, physical activity interventions for children achieve only small improvements in the time spent in MVPA. Although levels of MVPA significantly declined among participants in the control group,

activity levels were maintained in the intervention group. This finding is of considerable importance as it indicates that the intervention was protective against the decline in physical activity that is often observed in late childhood and early adolescence. Lopes and colleagues(26) demonstrated a similar physical activity maintenance effect over time, and suggested that increasing movement skills was the primary mechanism responsible for this result.

Paragraph Number 25 The intervention effect on MVPA observed in the current study may be attributed to the greater quality of PE and school sport delivered in the intervention schools, which were key intervention targets. The professional development provided to teachers focused on improving the quality of PE lessons which included appropriate FMS instruction and high levels of active learning time (i.e., the proportion of PE lesson time students spend in MVPA). A recent systematic review identified that school-based interventions can increase the proportion of time students spend in MVPA during PE lessons(25). Effective intervention strategies identified in the review included teacher professional development focusing on class organization, management and instruction(25), all of which were key areas for professional development and lesson observations in the SCORES intervention(28). This suggestion is further supported by the high adherence to the recommended PE lesson structure observed in the intervention school teachers, which improved over the intervention period.

Paragraph Number 26 The SCORES intervention resulted in a significant group-by-time interaction for after-school and weekend MVPA. This is a notable finding as the after-school period in particular, is considered the critical window of opportunity for young people to be physically active. Children have more discretion over how they spend their time after-school and on weekends. The maintenance of MVPA during these time periods indicates that the intervention was successful in preventing children from selecting sedentary recreational

activities. Although the within school MVPA group-by-time interactions were not significant, participants in the intervention group were spending four minutes more in MVPA compared to those in the control group.

Paragraph Number 27 Improvements in FMS competency were observed in both the intervention and control groups at mid-program and posttest; however improvements were greater in the intervention group. The increase observed in both groups is likely due to maturation and natural development that occur during childhood. Findings from the current study are consistent with a recent systematic review(32) which concluded that enhanced PE programs that use PE specialists or provide professional development for teachers can increase the rate of skill development in children. The review also highlighted the benefit of student-centered approaches to FMS teaching(9, 21), in particular approaches that adopted a mastery climate, focusing on success, optimal challenge and autonomy. Aligning with recommendations from this review, the SCORES intervention used professional development, and mastery climate approaches.

Paragraph Number 28 Although there was a significant group-by-time interaction for overall FMS at posttest, the mid-program effect was not statistically significant. Movement skill acquisition is a developmental process, over time, involving a large degree of variability in movement patterns. With quality learning opportunities, individuals progress through stages from rudimentary to more advanced movement skill patterns with improved performance and consistency. The lack of significant effects for FMS at mid-program could be attributed to the quality of instruction by the teachers not being adequate to result in improvements in the children's skills above and beyond natural development. Improvements in the quality of PE lessons, as per the lesson observations, were seen after the mid-point of the intervention. The lack of significant effects at mid-program, but significant effects found at posttest supports the notion it takes time, practice and quality feedback from qualified personnel to increase the

rate of skill development. It is possible that the non-significant mid-program findings were due to the combined MVPA/skill development aim for PE. Although teachers were provided with strategies to maximise both opportunities for skill development and physical activity, in the early stages of the intervention, teachers may have found it challenging to achieve both outcomes. Based on the process evaluation data, teachers improved their lesson quality over time and demonstrated a capacity to adhere to the desired SCORES lesson structure as the intervention progressed.

Paragraph Number 29 As expected with maturation, cardiorespiratory fitness increased in both the intervention and control groups at mid-program. However, by posttest, the significant increase in cardiorespiratory fitness was sustained only in the intervention group. The SCORES intervention was found to have a significant group-by-time interaction for cardiorespiratory fitness, equivalent to five additional laps on the multistage fitness test. This finding is substantial considering the low levels of fitness observed among young people, and the decline in cardiorespiratory performance over recent decades(40). Other high quality school-based interventions have also reported improvements in cardiorespiratory fitness(14, 22, 36). Interestingly, many of these trials have used PE specialists to deliver their programs, which have sometimes included daily physical activity sessions. Alternatively, SCORES achieved improvements in cardiorespiratory fitness with the generalist classroom teacher delivering the program and without additional sessions per week. It is plausible to suggest that the SCORES intervention strategies targeting physical activity within and beyond the school day (e.g., lunch and recess organized games, FMS homework, 50% of PE and sport time devoted to MVPA) over an extended period of time, contributed to improvements in cardiorespiratory fitness.

Paragraph Number 30 Interestingly, none of the intervention effects for the primary outcomes were significant at mid-program. Overall there was good compliance to the

intervention strategies, however the lack of findings at mid-program may be because it takes time for the intervention components to become adopted and implemented. Furthermore, the lack of significant findings at mid-program may be due to the intervention being delivered in a three phase approach meaning that not all components were employed in the first 6-months. Phase 1 involving the teacher professional development, student leadership, provision of equipment and establishment of a school committee were implemented prior to the 6-month assessments. While teachers reported that they found the workshops to be useful for effective PE teaching strategies, improvement in the quality of their PE lessons, as per the lesson observations, were seen after the mid-point of the intervention. There was good attendance at the student leadership workshop however schools commented that it took some time to implement the student leadership tasks and award system, which may have contributed to less physical activity opportunity in the first period of the intervention. Phase 2 and 3 involved school physical activity promotion policies, strategies to target the home environment, and improve school-community links, all of which were implemented during and after the 6-month assessments. Parent engagement and community link strategies appeared to be successful with good compliance and satisfaction as demonstrated in the process evaluation measures. Adherence to school physical activity policies ranged. School principals commented that low adherence to some policies (e.g., FMS reporting) was due to adoption and implementation of these policies being more appropriate and practical at the start of the school year rather than halfway through as designed in the intervention.

Paragraph Number 31 The positive results in the current study were found in a population subgroup (i.e. low socio-economic background) that is at elevated risk of the consequences of physical inactivity. The primary school years are the optimal time for developing children's physical activity behaviors and FMS(17). PE is a vital medium for providing developmental opportunities, and the quality of instruction is one of the most influential factors in children's

development(17). Current issues (i.e. inadequate teachers training, crowded curriculum)(33) within the primary school PE learning context need to be addressed so that children can receive continual, progressive quality instruction. Adopting successful evidenced-based approaches may assist in improving the current low levels of primary school aged children's physical activity, FMS and cardio-respiratory fitness(20), especially in those who are at most risk (i.e. low socio-economic backgrounds), and the dire state of Australian primary school PE(11). Promotion of positive health related behaviors and outcomes (i.e., physical activity, FMS and cardiorespiratory fitness) in early life is important and expected to have long term benefits. Utilizing the established personnel and resources in the school setting, combined with effective evidence-based strategies, such as SCORES, may be a practical method of early physical activity intervention.

Strengths and limitations

Paragraph Number 32 The strengths of this study include the cluster randomized controlled trial design, comprehensive multi-component intervention, the objective measures of physical activity, FMS, and cardiorespiratory fitness, adjustment of all analyses for confounders, and a high level of participant retention for FMS (81.1%) and cardiorespiratory fitness (84.7%). However, there are some limitations that should be noted. First, despite implementing a range of strategies (e.g., text messages and prizes) to improve accelerometer monitoring compliance, only a small number of participants provided useable accelerometer data at baseline (54.3%) and posttest (30.0%). Although accelerometers are considered to be the optimal method for assessing change in physical activity, compliance to monitoring protocols is often poor, particularly among children of low socio-economic status(37). Children who are socially disadvantaged or who live in disadvantaged areas are significantly less likely to provide reliable accelerometer data(37). Studies that measure only weekday or school-time (i.e., 9am-3pm Monday to Friday or break-time) physical activity tend to achieve higher rates

of compliance. This was observed in the current study with higher baseline (70.7%) and posttest (46.3%) weekday compliance. Often higher school-time compliance is attributed to teachers being responsible for children putting accelerometers on at start of the school day and collecting the monitors at the end of the day, thus reducing the challenges of poor compliance outside of the school setting. Alternatively, wrist worn accelerometers may be more acceptable for young people, resulting in higher rates of compliance. Finally, lack of a long-term follow-up is an additional study limitation.

CONCLUSION

Paragraph Number 33 The SCORES intervention resulted in significant group-by-time interactions for children's daily MVPA minutes, overall FMS competency, and cardiorespiratory fitness. The findings demonstrate the potential for multi-component school-based interventions to promote physical activity, movement skill competency and fitness in children attending primary schools in low-income communities.

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Figure 1 Caption:

Figure 1. Study design and flow of participants through study with primary outcome measures.

^a Children either arrived late to school or left school early on the assessment day; ^b Children were absent on the assessment day; ^c Children left the school; ^d Children withdrew from the program.