Evaluation of a School-based Physical Activity and Fundamental Movement Skill Intervention for Children Living in Low-income Communities: The Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES) Cluster Randomised Controlled Trial

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Statement of Originality

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution, and to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. I give consent to the final version of my thesis being made available worldwide when deposited in the University's Digital Repository, subject to the provisions of the Copyright Act 1968.

Signed: _____

Name: Kristen Emilie Cohen (*nee Weaver*)

Date: 22/12/2015

Thesis by Publication

I hereby certify that this thesis is in the form of a series of published papers of which I am a joint author. I have included as part of this thesis a written statement from each co-author, endorsed by the Faculty Assistant Dean (Research Training), attesting to my contribution to the joint publications.

Signed: _____

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Publications arisisng from this thesis

This thesis is presented as a series of six papers. I am the lead author on four papers and am co-author for two papers. At the time of submission, five of these papers were published and one was under review.

Manuscripts in peer-reviewed journals: Published

1. Lubans, D.R., Morgan, P.J., **Weaver, K.E.,** Callister, R., Dewar, D.L., Costigan, S.A., Finn, T.L., Smith, J., Upton, L., & Plotnikoff, R.C. (2012). Rationale and study protocol for the SCORES group randomized controlled trial: A physical activity and fundamental movement skills intervention for primary schools in low-income communities. *BMC Public Health*, 12(1): 427-438. (IF 2.264)

2. Morgan, P.J., Barnett, L.M., Cliff, D.P., Okely, A,D., Scott, H.A., **Cohen, K.E.,** & Lubans, D. R. (2013). Effectiveness of interventions to improve fundamental movement skill proficiency in youth: a systematic review and meta-analysis. *Pediatrics*, 132(5): e1361–e1383. (IF 5.473)

3. **Cohen, K.E.,** Morgan, P.J., Plotnikoff, R.C., Callister, R., & Lubans, D.R. (2014). Movement skills and physical activity among children living in low-income communities: a cross sectional study. *International Journal of Behavioral Nutrition and Physical Activity*, 11(1): 49-57. (IF 4.111)

4. **Cohen, K.E.,** Morgan, P.J., Plotnikoff, R.C., Callister, R., & Lubans, D.R. (2015). Physical activity and skills intervention: SCORES cluster randomized controlled trial. *Medicine and Science in Sports and Exercise*, 47(4): 765-774. (IF 4.475)

5. **Cohen, K.E.,** Morgan, P.J., Plotnikoff, R.C., Barnett, L.M, & Lubans, D.R. (2015). Improvements in fundamental movement skill competency mediate the effect of the SCORES intervention on physical activity and cardiorespiratory fitness in children. *Journal of Sports Sciences*, 33(18): 1908-1918. (IF 2.246)

Manuscripts in peer-reviewed journals: Under review

1. **Cohen, K.E.,** Morgan, P.J., Plotnikoff, R.C., & Lubans, D.R. (under review). Psychological, social and physical environmental mediators of the SCORES intervention on physical activity among children living in low-income communities. *Journal of Behavioral Medicine*. (IF 2.959)

Additional Publications Co-authored During Candidature

Manuscripts in peer-reviewed journals: Accepted for publication

1. Barnett, L.M., Stodden, D., **Cohen, K.E.,** Smith, J., Lubans, D.R., Lenoir, M.E.M., Iivonen, K.S., Miller, A., Laukkanen, A.I., Dudley, D.A., Lander, N.J., Brown, H., & Morgan, P.J. (in press). Fundamental Movement Skills: An Important Focus. *Journal of Teaching in Physical Education.* (IF 0.74)

Presentations arisisng from this thesis

I presented results arising from this thesis at two international and two national conferences (three oral presentations; one poster presentation). Co-authors presented results arising from this thesis at one international and one national conference (two oral presentations).

Presentataions: Refereed Conference Abstracts

1. **Weaver, K.E.,** Lubans, D.R., Morgan, P.J., Callister, R., Dewar, D.L., Finn, T.L., Smith, J., & Plotnikoff, R.C. (2012). Rationale and intervention description of the Supporting Children's Outcomes using Rewards, Exercise and Skills physical activity intervention. *4th International Congress on Physical Activity and Public Health, Australian Conference of Science and Medicine in Sport, 31 October-3 November 2012, Sydney, Australia. Journal of Science and Medicine in Sport, 15(6) (Dec 2012 Suppl.), 203*: Poster presentation.

2. **Cohen, K.E.,** Morgan, P.J., Plotnikoff, R.C., Callister, R., & Lubans, D.R. (2014). Fundamental movement skill competency and objectively measured physical activity among children attending primary schools in low-income communities. *International Association for Physical Education in Higher Education (AIESEP) World Congress 2014.* University of Auckland, New Zealand, 10-13 February: Oral presentation.

3. Morgan, P.J., Scott, H.A., **Cohen, K.E.,** Lubans, D.R., Barnett, L.M., Cliff, D.P., & Okely, A.D. (2014). A systemic review of evidence for the benefits of fundamental movement skills interventions targeting youth. *International Association for Physical Education in Higher Education (AIESEP) World Congress 2014*. University of Auckland, New Zealand, 10-13 February: Oral presentation.

4. **Cohen, K.E.,** Morgan, P.J., Plotnikoff, R.C., Barnett, L.M, & Lubans, D.R. (2014). Improving fundamental movement skill competency among children attending schools in low-income communities: The SCORES cluster RCT. *Australian Conference of Science and Medicine in Sport/ National Physical Activity Conference/ National Sports Injury Prevention Conference., 15 - 18 October 2014, Canberra, Australia. Journal of Science and Medicine in Sport, 18(6) (Dec 2014 Suppl.), 236*: Oral presentation.

5. Lubans, D., **Cohen, K.E.,** Plotnikoff, R., Callister, R., & Morgan, P. (2014) The SCORES physical activity intervention for children attending schools in low-income communities: A cluster RCT. *Australian Conference of Science and Medicine in Sport/ National Physical Activity Conference/ National Sports Injury Prevention Conference, 15 - 18 October 2014, Canberra, Australia. Journal of Science and Medicine in Sport, 18(6) (Dec 2014 Suppl.), 176:* Oral presentation.

6. **Cohen, K.E.,** Morgan, P.J., Plotnikoff, R.C., Barnett, L.M, & Lubans, D.R. (2015). Improvements in fundamental movement skill competency mediate the effect of the SCORES intervention on physical activity and cardiorespiratory fitness in children. *Australian Conference of Science and Medicine in Sport, 21 - 24 October 2015, Gold Coast, Australia. Journal of Science and Medicine in Sport, 18(6) (Dec 2015 Suppl.), 199*: Oral presentation.

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List of Abbreviations

BMI	Body mass index
BMI z-score	Body mass index z-score
CI	Confidence interval
CMT	Competence Motivation Theory
CONSORT	Consolidated Standards Of Reporting Trials
FMS	Fundamental movement skills
Kg	Kilogram
Min	Minutes
MVPA	Moderate-to-vigorous physical activity
N	Number
NSW	New South Wales
PA	Physical activity
PE	Physical education
RCT	Randomised controlled trial
SCORES	Supporting Children's Outcomes using Rewards, Exercise and Skills
SD	Standard deviation
SDT	Self-Determination Theory
SEIFA	Socio-economic indices for areas
SES	Socio-economic status
SPANS	Schools Physical Activity and Nutrition Survey
TGMD-2	Test of Gross Motor Development 2
WHO	World Health Organisation

Note. This list represents the abbreviations used in the main text of this thesis. Additional abbreviations in tables are defined in the bottom row.

Definitions

Adolescent	Individuals 13-18 years of age.
Child	Individuals 5-12 years of age.
Fundamental movement skills	Gallahue and Donnelly define FMS as ‘an organised series of basic movements that involve the combination of movement patterns of two or more body segments’ [1]. In this thesis FMS will be categorised as locomotor skills (i.e., run, jump, skip, side gallop, gallop, and hop), object-control skills (i.e., overarm throw, underhand roll, kick, two-hand strike, catch, and dribble) and overall FMS (i.e., locomotor skills and object-control skills).
Physical activity	The WHO defines physical activity as ‘any bodily movement produced by skeletal muscles that requires energy expenditure’ [2].
Youth	Individuals 5-18 years of age.

Thesis Abstract

Background

Many Australian children are insufficiently active to accrue the associated health benefits. Physical activity levels are also consistently lower among children of low socio-economic status (SES) than children of middle- and high-SES. Physical activity levels decline dramatically during adolescence and evidence suggests that competency in a range of fundamental movement skills (FMS) may serve as a protective factor against this trend. Schools offer an ideal setting to promote physical activity and increase FMS competency in children. However, previous school-based interventions have had small effects on increasing children's physical activity, which may be attributed to the lack of a theoretical framework for guiding behaviour change, failure to address the multiple components that influence physical activity behaviour in and beyond the school setting, and methodological weaknesses. Currently, an evidence gap exists for effective, theoretically framed, multi-component school-based physical activity and FMS interventions for children located in low-income communities.

Objectives

This thesis by publication presents a series of studies that were conducted to address this gap in the literature. Overall, these studies relate to: i) the utility of FMS for promoting physical activity in children and the effectiveness of FMS interventions; and ii) the development of the primary school-based Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES) intervention and its evaluation via a cluster randomised controlled trial (RCT).

The primary aim of this thesis was to evaluate the impact of the SCORES intervention on moderate-to-vigorous physical activity (MVPA), cardiorespiratory fitness and FMS competency among children attending primary schools located in low-income communities. Further, the thesis presents a series of studies investigating four key secondary aims, which are briefly described below. As these studies provide important context for the primary aim, the thesis is presented in the following order:

Secondary Aim 1: To systematically review the evidence of interventions designed to improve FMS competency in typically developing children and adolescents.

A literature search with no date restrictions was conducted across seven databases. Studies included any school-, home-, or community-based intervention for typically developing youth with clear intent to improve FMS competency and that reported statistical analysis of FMS competence at both pre-intervention and at least one other post-intervention time-point. Study designs included RCTs using experimental and quasi-experimental designs and single group pre-post trials. Risk of bias was independently assessed by two reviewers. Twenty-two articles (six RCTs, 13 quasi-experimental trials, three pre-post trials) describing 19 interventions were included. All but one intervention were evaluated in primary/elementary schools. All studies reported significant intervention effects for ≥ one FMS. Meta-analyses revealed large effect sizes for overall gross motor proficiency (standardized mean difference [SMD] = 1.42, 95% confidence interval [CI] 0.68 to 2.16, Z = 3.77, $p < .0002$) and locomotor skill competency (SMD = 1.42, 95% CI 0.56 to 2.27, Z = 3.25, $p = .001$). A medium effect size for object control skill competency was observed (SMD = 0.63, 95% CI 0.28 to 0.98, Z = 3.53, $p = .0004$). Risk of bias was high among the majority of studies.

Secondary Aim 2: To examine the association between FMS competency and objectively measured MVPA during time periods of the day that represent key physical activity opportunities (i.e., lunchtime, recess and after-school) among children attending primary schools located in low-income communities.

Using baseline data from the SCORES cluster RCT, multilevel linear mixed models were used to assess the cross-sectional associations between FMS and objectively measured MVPA. After adjusting for age, sex, BMI and SES (measured at the individual level), locomotor skill competency was positively associated with total MVPA ($p = 0.002$, $r = 0.15$) and after-school MVPA ($p = 0.014$, $r = 0.13$). Object-control skill competency was positively associated with total MVPA ($p < 0.001$, $r = 0.20$), lunchtime MVPA ($p = 0.03$, $r = 0.10$), recess ($p = 0.006$, $r = 0.11$) and after-school MVPA ($p = 0.022$, $r = 0.13$).

Primary Aim: To evaluate the impact of the Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES) intervention on MVPA, cardiorespiratory fitness and FMS competency among children attending primary schools located in low-income communities.

The SCORES intervention, which was a multi-component physical activity and FMS intervention for primary schools located in low-income communities, was evaluated using a cluster RCT. The socio-ecological model provided a framework for the 12-month intervention, which included the following components: teacher professional learning, student leadership workshops, physical activity policy review, equipment packs, parental engagement via newsletters, FMS homework and a parent evening, and community partnerships with local sporting organisations. The sample included 25 classes from eight 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 MVPA (ActiGraph GT3X and GT3X+ accelerometers), FMS competency (TGMD-2; six locomotor and six 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, SES, ethnicity and school class (as a random factor), were used to assess the impact of the intervention. 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 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).

Secondary Aim 3: To determine if changes in FMS competency and perceived competence mediate the effect of the SCORES intervention on MVPA and cardiorespiratory fitness among children attending primary schools located in low-income communities.

Mediation analyses were conducted using multilevel linear analysis in MPlus. There were significant treatment effects for locomotor skills (A = 1.76, SE = 0.88, p = 0.044) and overall FMS (A = 4.09, SE = 2.08, p = 0.049). Changes in MVPA were

associated with changes in object-control skills (B = 0.86, SE = 0.15, $p < 0.001$), overall FMS (B = 0.51, SE = 0.10, $p < 0.001$) and perceived competence (B = 0.48, SE = 0.36, $p = 0.027$). Overall FMS had a significant mediating effect on MVPA (AB = 2.09, 95% CI 0.01 to 4.55). Overall FMS (AB = 1.19, 95% CI 0.002 to 2.79) and locomotor skills (AB = 0.74, 95% CI 0.01 to 1.69) had a significant mediating effect on cardiorespiratory fitness.

Secondary Aim 4: To determine if changes in individual, social and physical environmental constructs mediate the effect of the SCORES intervention on MVPA among children attending primary schools located in low-income communities.

Hypothesised mediators measured in children via questionnaire were enjoyment of physical activity, perceived sport competence, and perceived social support. Hypothesised mediators measured in parents via questionnaire were social support from family, 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. There were significant intervention effects for social support from teachers (A = 1.73, SE = 0.88, $p = 0.048$) and 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, $p = 0.027$), perceived access to physical activity opportunities in the local community (B = 0.60, SE = 0.26, $p = 0.021$), and changes in total MVPA. 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).

Discussion

The studies included in this thesis contribute to the growing body of evidence for the utility of FMS to promote physical activity in children and the effectiveness of FMS and physical activity interventions. This thesis revealed that school- and community-based programs that include developmentally appropriate FMS learning experiences delivered by physical education (PE) specialists or highly trained classroom teachers significantly improve FMS competency in young people. In addition, object-control

skill competency was found to be a better predictor of children's MVPA during school-based physical activity opportunities than locomotor skill competency. In contrast, both object-control and locomotor skill competency were important for engagement in after-school MVPA. The SCORES intervention maintained daily MVPA, improved overall FMS competency and increased cardiorespiratory fitness among children attending primary schools in low-income communities. Of note, these effects were achieved without allocating additional curriculum time to PE or school sport. This provides evidence for the effectiveness of theoretically-framed, multi-component school-based physical activity and FMS interventions for children. Further, this was the first study to explore the mediating effects of FMS competency in a physical activity intervention in children. Improvements in overall FMS competency acted as a causal mechanism for physical activity behaviour change and subsequent improvements in cardiorespiratory fitness among children. Perceived access to physical activity opportunities in the local community was also identified as a mechanism of physical activity behaviour change in children. Additional research is needed to replicate the novel findings in this thesis and follow-up assessments beyond the post-intervention time point are needed to determine any sustained or long-term effects of future physical activity and FMS interventions.

Contribution Statement

This thesis contains four peer reviewed publications that relate to the SCORES cluster RCT. I was the sole PhD student of this study and I was involved in all aspects of the design, implementation and evaluation of the intervention. A summary of the contributions that I made to this study is provided below.

Intervention development

In collaboration with my supervisors, I lead the development of the following SCORES intervention components.

1) Professional learning workshops for teachers	• Content and resources for the Stage 2 teachers' professional learning workshops. • Content and resources for the whole-school professional learning workshops. • FMS activity book and activity cards.
2) Student leadership	• Content and resources for the student leadership workshop. • SCORES Leader handbook for students.
3) Policy and environment	• Conducted a review of effective school physical activity policies which guided the development of the school physical activity policies. • Implementation strategies and resources for the school physical activity policies. • Selected and ordered appropriate equipment that would promote physical activity and FMS development in the school.
4) Parental engagement	• Content for the four parent newsletters. • Content and resources for the parent evenings. • Content and resources for the FMS homework.

5)	Community links	• Local sporting organisations information sheets.

Data collection, entry and management

With our research assistant, I was responsible for planning and coordinating the comprehensive study assessments. The participants completed three assessment sessions over the 12-month study period at their primary school. With our research assistant, I created a standardised protocol manual for completing and administering the assessments. I also conducted comprehensive training sessions for all study assessors. With assistance from our research assistants, I was involved in the assessments at all time-points, as well as conducted a detailed process evaluation. I assisted the study research assistants with data entry, and was responsible for cleaning all entered data.

Program implementation

With support from my supervisors, I successfully implemented the five intervention components, as listed below, in the four intervention schools and following study completion, in the four control schools. Further, I was also the contact person for schools and parents during the study and was responsible for managing all enquires.

1)	Professional learning workshops for teachers	• Conducted one Stage 2 teachers' professional learning workshop. • Conducted four whole-school professional learning workshops. • Conducted three PE lesson observations for 12 Stage 2 teachers.
2)	Student leadership	• Conducted four student leadership workshops.
3)	Policy and environment	• Conducted four school physical activity policy meetings with school principals. • Conducted four whole-school workshops on

		implementation of the school physical activity policies. • Distributed sporting equipment to four schools.
4)	Parental engagement	• Distributed the four newsletters to parents / carers of the study participants. • Organised and conducted four parent evenings. • Distributed and explained the FMS homework to four schools.
5)	Community links	• Organised six visits to each school from local sporting organisations. • Distributed local sporting organisations information sheets.

Data analysis

With support from my supervisors, I completed the statistical analysis for the studies in Chapters Four to Seven of this thesis.

Presentation of Results

During my candidature, I presented results from my thesis at two international and two national conferences. These presentations are listed in the 'Presentations arising from this thesis' section.

Awards received during candidature

In 2014, I won an award at the Priority Research Centre for Physical Activity and Nutrition for ‘best published paper’ in the Physical Activity and Nutrition in Schools theme. In 2015, I won a University award for best paper in the Faculty of Education and Arts.

CHAPTER 1. INTRODUCTION

A rationale for promoting physical activity, cardiorespiratory fitness and FMS competency in children, and the importance of evidence-based physical activity interventions in the school setting is provided in this chapter. The benefits and prevalence of physical activity, cardiorespiratory fitness and FMS competency in children are summarised in the first section. Key influences on children's physical activity, including correlates, mediators, and theories of health behaviour are described in the second section. In section three, an overview of interventions to promote physical activity in children, focusing on school-based settings, specifically in low socio-economic status (SES) communities is included. Chapter 1 concludes with a description of the research aims and thesis structure. A summary of the structure of Chapter 1 is depicted in Figure 1.1.

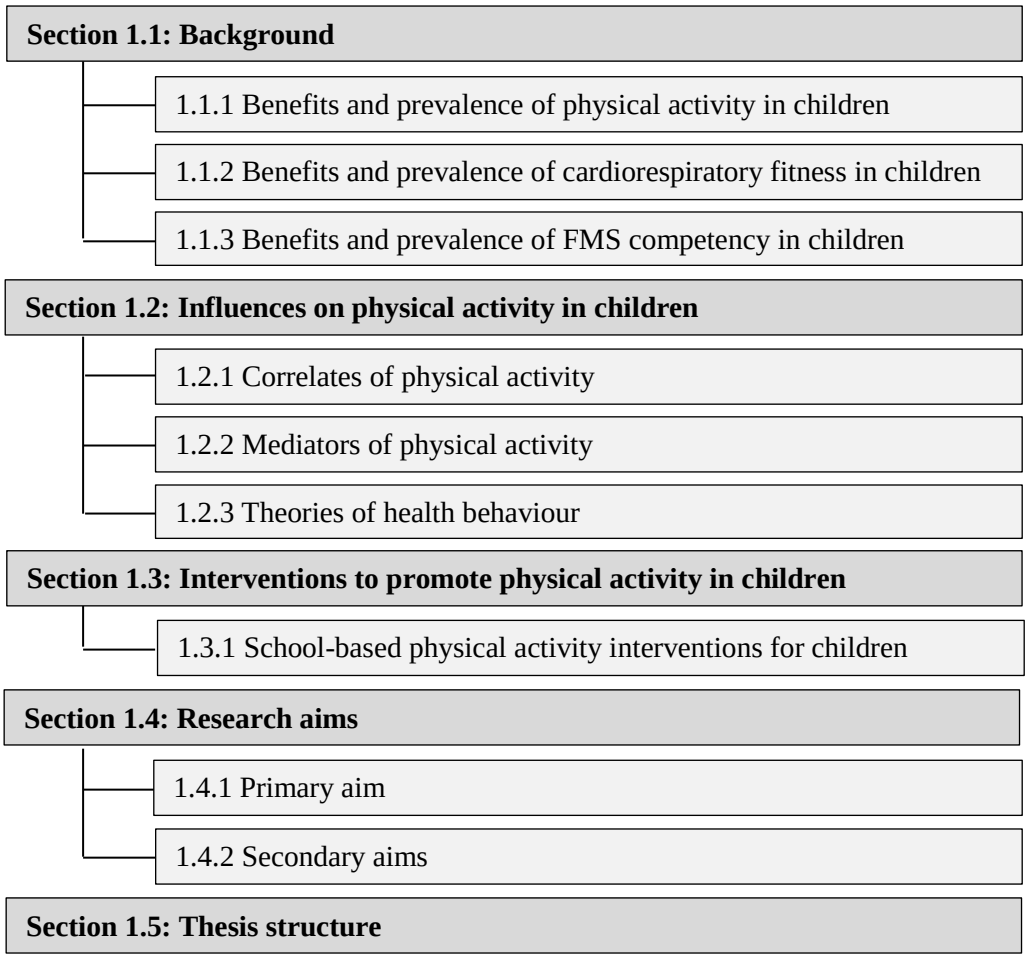

Figure 1.1 Structure of Chapter 1

1.1. Background

1.1.1. Physical activity

1.1.1.1. Benefits of physical activity for children

Participation in regular physical activity is a public health priority, and is essential for achieving numerous physical, social and psychological health benefits [3, 4]. There is overwhelming evidence for the beneficial effects of physical activity on adiposity, musculoskeletal health and fitness, blood pressure, several components of cardiovascular health, and mental health including self-concept, anxiety and depression in children [3]. Moreover, the greater the frequency and intensity of physical activity, the greater the health benefits [3].

1.1.1.2. Physical activity recommendations for children

Evidence-based guidelines have been developed which outline the recommended amount of daily physical activity for children and adolescents. Consistent with international guidelines [5, 6], the Australian physical activity guidelines recommend that children aged 5 to 12 years should:

i. participate in at least 60 minutes of moderate-to-vigorous intensity physical activity (MVPA) every day;
ii. include a variety of aerobic activities, including some vigorous intensity;
iii. engage in activities that strengthen muscle and bone on at least three days per week; and
iv. engage in more activity (up to several hours per day) to achieve additional health benefits [7].

The current physical activity guidelines have been equated to evidence-based step defined recommendations for children. It is recommended that boys accumulate 13,000 to 15,000 steps per day and girls accumulate 11,000 to 12,000 steps per day [8].

1.1.1.3. Physical activity levels of children

Physical inactivity has been described as a global pandemic [9]. This is consistent with a recent international review of report cards on physical activity from 15 countries [10]. The physical activity report cards provide a standardised grade for national physical activity levels of children and adolescents using nine common indicators, 1) overall physical activity; 2) organised sport participation; 3) active play; 4) active transportation; 5) sedentary behaviour; 6) family and peers; 7) school; 8) community and built environment; and 9) government strategies and investments. Ten of the fifteen countries involved in the review reported poor levels, with approximately 20% of children and adolescents meeting the above stated physical activity guidelines, suggesting there is widespread evidence of a 'childhood physical inactivity crisis' in developed countries [10].

Current Australian estimates report only 28% of Australian primary school-aged children meet the recommended physical activity guidelines [11, 12], and on average only take 9,140 steps each day [11, 12]. Studies that employ self-report measures estimate physical activity levels to be higher. For example, a state-based report in NSW reported that approximately 50% of primary school-aged children meet the physical activity guidelines [13]. However, estimates from studies using self-reported data should be interpreted with caution as such measures are limited by participants' ability to accurately recall their behaviours [14].

Of particular concern is the global evidence for a marked SES disparity in children's physical activity behaviour [15-17]. Current Australian evidence is consistent with global findings, with youth from low-SES backgrounds being less active than those of middle- and high-SES backgrounds [13, 18, 19]. In Australia, 18% fewer primary school-aged children from low-SES population groups met the physical activity guidelines than children from middle- and high-SES population groups [13]. However, this prevalence may be higher as these finding were based on self-reported physical activity. A study tracking physical activity levels from 1990-2002 among Scottish schoolchildren also found physical activity was consistently lower among lower SES population groups [20]. Furthermore, studies conducted among South African children [21] and Canadian adolescents [22] have reported similar results.

This disparity is often attributed to individuals from low-SES populations having reduced opportunities and access to physical activity facilities and resources, with cost identified as a major barrier [23, 24].

1.1.1.4. Measurement of physical activity

The accurate assessment of physical activity is needed to evaluate the effectiveness of interventions, monitor trends in behaviour and understand the association between physical activity and health outcomes [25]. For accuracy of assessment, it is imperative the instrument/method is: 1) valid i.e., the instrument measures what it is intended to measure; 2) reliable i.e., the instrument consistently provides the same results under the same conditions; 3) non-reactive i.e., the instrument must not modify the population or the behaviour it aims to measure; and 4) practical i.e., the instrument has acceptable cost to the participant and the researcher [26]. The selection of measurement instrument is dependent upon the purpose of the study, the size of the study population, and the availability of resources [26].

A variety of methods have been used to assess physical activity, and generally, these methods are grouped into subjective and objective categories. Subjective measures include: self-report questionnaires, diaries/logs, parent report and teacher report. Objective measures include: heart rate monitoring, observation, accelerometry, and pedometry [26]. Subjective measures, such as self-report questionnaires, are the most common method used as they are efficiently administered in large studies or at the population level, and tend to be more acceptable [26]. However, the challenge with subjective measures is the error associated with participant recall (approximately 35 to 50% error rate in youth) [25, 27]. The inaccuracy of subjective measures can be attributed to cognitive development, biased reporting and low validity of measures [27-29].

Objective measures, such as accelerometers and pedometers, provide more accurate measures of physical activity. The ability of accelerometers to provide an accurate, reliable, and practical objective measure of physical activity in children and adolescents has been recognised in a number of reviews [30-32]. As well as the increased accuracy of measurement, accelerometers are viewed as the preferred

method by researchers, as accelerometers provide information relating to the intensity, frequency, and duration of the physical activity performed [25]. However, there are recognised methodological challenges associated with accelerometer use [25]. A lack of standardised protocols for accelerometer use (e.g., wear time, epoch length, valid day criteria) makes comparisons among studies difficult, and low adherence rates to monitoring protocols appear to be a consistent challenge for researchers [25, 33]. Furthermore, accelerometers are unable to detect non-ambulatory activity and cannot be worn in the water or while playing contact sports.

1.1.2. Cardiorespiratory fitness

1.1.2.1. Benefits of cardiorespiratory fitness for children

Low levels of cardiorespiratory fitness are a significant risk factor for the development of cardiovascular diseases [34, 35], insulin resistance [36] and type 2 diabetes [37], low levels of mental health [38], and all-cause mortality [39]. Children who are adequately fit are more likely to have high levels of cardiorespiratory fitness and participate in more physical activity as an adult [40]. The foundation for cardiovascular disease commences in childhood, and evidence suggests that high levels of cardiorespiratory fitness during childhood may result in a healthier cardiovascular profile in adulthood [41].

1.1.2.2. Cardiorespiratory fitness levels of children

There has been a steep global decline in children's cardiorespiratory fitness in recent decades, equating to -0.36% per annum [42]. Secular changes have been very consistent across age, sex and geographical locations; however, it was not consistent over time, with improvements from the late 1950s until about 1970 observed, and declines of increasing magnitude every decade thereafter [42]. Current Australian estimates report only 60% of Australian primary school age children are adequately fit, with the prevalence of cardiorespiratory fitness significantly lower among children from low-SES backgrounds compared to children from high-SES backgrounds [13].

1.1.2.3. Measurement of cardiorespiratory fitness

Cardiorespiratory fitness can be measured using either laboratory-based or field-based methods. Laboratory-based methods, such as maximal oxygen uptake [43], are deemed the 'gold standard' measure as they objectively and accurately measure a participant's cardiorespiratory fitness level. However, such methods are limited in some settings, for example schools, due to the high costs, time constraints, requirement of sophisticated instruments and qualified personnel [44, 45]. Alternatively, field-based methods are more appropriate for school-based and population-level research, as they are time-efficient, low cost, require minimal equipment and a large number of participants can be assessed simultaneously [44, 45]. A total of 12 field-based tests have been identified to assess cardiorespiratory fitness, with the 20-metre shuttle run test [46] and the 1-mile run [47], commonly used in youth. Of the 12 field-based tests identified, the 20-metre shuttle run test is considered to have acceptable validity and reliability [44] and is currently recommended by the Institute of Medicine [48] for assessing cardiorespiratory fitness in children and adolescents.

1.1.3. Fundamental movement skills

FMS are defined as "organised series of basic movements that involve the combination of movement patterns of two or more body segments" (p. 52) [1]. FMS are often categorised into three groups: locomotor (e.g., run, hop, jump, leap, gallop, slide/side gallop), object-control or manipulative (e.g., overarm throw, catch, kick, strike, dribble, underhand roll), and stability (e.g., static balance) skills [49]. These skills form the foundation for future movement and physical activity. The development of FMS leads to specialised movement sequences required for participation in many organised and non-organised physical activities. The unique component of FMS is the transfer of skills. The development of one movement skill pattern, for example the overarm throw, can be refined and applied into a variety of context specific skills and activities such as the "serve" in tennis, the "shoulder pass" in netball, the "spike" in volleyball and the "pitch" in baseball [50].

1.1.3.1. Health benefits of FMS competency in children

A recent systematic review found evidence for the association between FMS competency and a range of physiological, psychological, and behavioural health outcomes in children and adolescents [51]. Strong evidence from cross-sectional studies was found for a positive association between FMS competency and physical activity in children and adolescents [51]. A longitudinal study identified in the review, found a positive association between childhood object-control skill competency and adolescent physical activity [52]. A positive association was also found between FMS competency and cardiorespiratory fitness, and an inverse association between weight status and FMS competency [51]. Perceived competence, which is an individual's perception of their actual movement proficiency, is positively associated with FMS competency [53-55] and may act as mediator of the association between FMS and physical activity [53].

1.1.3.2. FMS competency of children

Globally, children's FMS competency is low [13, 56, 57], with many children progressing into adolescence without competency in these core movement skills. A recent study examined trends of Australian school-aged children's FMS competency over a 13-year period [58]. Overall, FMS competency at each time point was low, with prevalence of competency very rarely above 50% for primary school-aged children. Between 1997 and 2004 there were significant increases in competency of the sprint run, vertical jump and catch, and for boys, competency increased in the kick. Between 2004 and 2010 competency increased for the catch in all students and in girls the kick, however competency for the vertical jump decreased, and overall FMS competency has remained low (<50%) [58]. Table 1.1 provides an overview of the prevalence of FMS competency among boys and girls by year group from the NSW Schools Physical Activity and Nutrition Survey 2010 [13]. Furthermore, children from low-SES backgrounds often demonstrate lower levels of competency in comparison to those from middle- and high-SES backgrounds [13, 59, 60].

Table 1.1 Prevalence of FMS competency among boys and girls by year group from the NSW Schools Physical Activity and Nutrition Survey [13]

Skill	Year 2		Year 4		Year 6	
	Boys	Girls	Boys	Girls	Boys	Girls
Sprint Run						
Mastery (%)	17.5	12.8	21.3	18.5	22.8	23.5
Vertical Jump						
Mastery (%)	6.5	11.5	16.3	18.9	22.5	20.9
Side Gallop						
Mastery (%)	16.2	16.2	30.9	31.8	43.7	52.6
Leap						
Mastery (%)	1.4	4.9	4.7	13.9	5.7	18.2
Kick						
Mastery (%)	7.1	0.3	24.5	4.2	34.2	6.0
Overarm Throw						
Mastery (%)	9.0	1.3	24.3	3.0	32.1	7.8
Catch						
Mastery (%)	18.1	8.0	44.6	22.6	57.6	37.9

1.1.3.3. Measurement of FMS

Instruments used to measure FMS competency are commonly classified as either product or process orientated. Product instruments, such as the Körperkoordinations Test für Kinder (KTK) [61], are outcome-based and measure, for example successful attempts, distance or time [62]. Process instruments, such as the Test of Gross Motor Development-2 (TGMD-2) [63] and Get Skilled, Get Active [64], are concerned with how the skill is performed, that is, the quality of the movement rather than the outcome [62]. Product [65-67] and process [68-70] instruments have been used in studies investigating movement skill competency and physical activity. Both methods are appropriate for assessing movement competencies of children, with the selection of instrument based on the study purpose and outcomes of focus. Process instruments allow the accurate identification of specific skill competencies that may need improving [63]. This form of assessment is commonly used and is more relevant for research conducted in the school setting, as research in this setting generally aims to improve the quality of children's movement skills. The TGMD-2 is a commonly used process instrument in the school-setting and has established validity and reliability in children [63].

1.2. Influences on physical activity in children

Physical activity behaviour is complex and multi-dimensional, particularly during childhood and adolescence. Identifying the variables that influence physical activity behaviour is essential for understanding the complexity of behaviours and contributes to evidence based-planning of public health interventions [71].

1.2.1. Correlates of physical activity in children

Correlates are defined as statistical associations between measured variables and the outcome of interest (i.e., physical activity), which are established from cross-sectional analyses [71]. Correlates of physical activity behaviour are commonly classified as individual, social and environmental, and are often categorised by levels of the ecological model (Figure 1.2) [72].

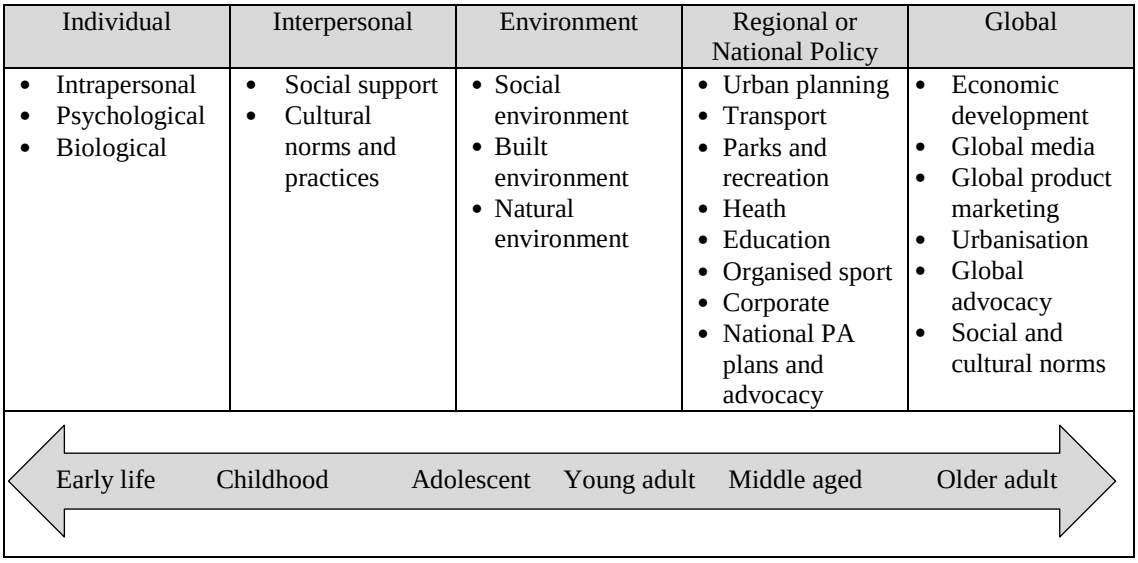

Figure 1.2 Adapted ecological model of the correlates of physical activity [72]

Table 1.2 provides an overview of the demographic and biological, psychological, behavioural, social and physical environment correlates of physical activity in children as identified by Bauman and colleagues [72]. Following Table 1.2 each of the categories will be briefly discussed in turn.

Table 1.2 Systematic reviews of correlates of physical activity in children [72]

Category	Study				
	Sallis 2000 [73]	Davison 2006 [74]	Van der Horst 2007 [17]	Hinkley 2008 [75]	Edwardson 2010 [76]
Demographic and biological variables					
Sex (male)	+	nr	+	+	nr
Ethnic origin (white)	?	nr	x	x	nr
Marital status of parent	x	nr	x	nr	nr
BMI or anthropometry	?	nr	x	x	nr
Psychosocial variables					
Perceived competence	?	nr	nr	nr	nr
Self-efficacy	?	nr	+	nr	nr
Attitude	x	nr	nr	nr	nr
Perceived behavioural control	nr	nr	nr	nr	nr
Value of health and status	nr	nr	nr	nr	nr
Barriers to physical activity	-	nr	x	nr	nr
Behavioural variables					
Previous physical activity	+	nr	nr	nr	nr
Smoking	x	nr	nr	nr	nr
Social and cultural variables					
Perceived parental role model	nr	nr	nr	nr	nr
Parent activity	?	nr	nr	+	x
Support for physical activity	nr	nr	nr	nr	nr
Support for physical activity from parents and family	nr	nr	+	nr	nr
Physical environment variables					
Access to facilities, programs and recreational areas	+	+	x	nr	nr
Proximity of playgrounds and parks	nr	+	nr	+	nr
Time outdoors	+	nr	nr	+	nr
PA related policies in school	nr	nr	nr	nr	nr
Crime and area deprivation	nr	-	nr	nr	nr
Road hazards	nr	-	nr	nr	nr

Note: + = Correlate (positive); - = Correlate (negative); x = Not correlated; ? = Inconclusive; nr = Not reported.

1.2.1.1. Demographic and biological correlates in children

Sex is a consistent correlate in children, with boys participating in significantly more physical activity than girls [72]. SES has also been identified as a correlate of children's physical activity, with children from low-SES populations less active than those from middle- or high-SES populations [15, 77-79]. There is no consistent

evidence for BMI or other anthropometric measures and white ethnic origin as correlates of children's physical activity [72].

1.2.1.2. Psychological correlates in children

Self-efficacy is a consistent positive correlate of physical activity in children [72]. Alternatively, inconsistent associations have been reported for perceived competence, enjoyment, and barriers to physical activity [72, 78]. Moreover, there is inconclusive evidence for perceived behavioural control, valuing physical activity for health status, and attitude as correlates of children's physical activity [72].

1.2.1.3. Behavioural correlates in children

Previous participation in physical activity [72] and FMS competency [51] are consistent positive correlates of children's physical activity. Inconsistent associations have been found for sedentary time, and participation in organised sport is indeterminate as this association is seldom studied [78].

1.2.1.4. Social environment correlates in children

The social environment encompasses the social relationships and cultural settings within which individuals function and interact [80]. Family and parent support are consistent positive correlates of children's physical activity [72]. There is inconclusive evidence for peer social support and support from significant others (e.g., teachers, other adults) as correlates, primarily due to few studies exploring this association in children [78].

1.2.1.5. Physical environment correlates in children

Access to facilities, programs and recreational areas, and proximity of playgrounds and parks are identified as positive correlates of physical activity in children. Time spent outdoors and physical activity related policies in schools have also emerged as positive correlates of children's physical activity. Crime and area deprivation, road hazards and distance to school are negative correlates of physical activity in children [78].

1.2.1.6. Summary

There is conclusive evidence for individual, social and environmental correlates in children, indicating that there are several levels of influence on children's physical activity behaviour, of which, many are modifiable [72, 78]. However, inconclusive evidence has been found for a number of variables, and some potential correlates remain indeterminate, indicating the need for further research in this area. Moreover, future research needs improved measures of physical activity, with the use of objective measures recommended, and increased physical activity correlate research in low and middle income countries, socially disadvantaged groups and obese individuals is suggested [72]. Although, correlates provide evidence of the association between a variable of interest and physical activity, the major limitation is that cause-and-effect relationships cannot be inferred [71].

1.2.2. Mediators of physical activity in children

A mediator is an intervening causal variable necessary to complete the pathway from an intervention to the targeted behavioural outcome [71]. Mediators assist in establishing the cause-and-effect relationship between an intervention and a behaviour, and allows researchers to understand "what worked" [71]. Despite their importance, few studies have assessed mediators of physical activity in interventions among children [81, 82]. In a review of mediators of behaviour in interventions to promote physical activity among children and adolescents, only seven studies satisfied the criteria for inclusion and all were conducted in secondary schools [81]. Self-efficacy was the most commonly assessed mediator and there was some support for its role in mediating theory-based interventions and physical activity. However, due to the variability in study designs, methods and results, strong conclusions were difficult to draw.

An updated review of 24 studies, conducted by van Stralen and colleagues [82], found that psychological (e.g., self-efficacy, attitude and self-regulation) and social (e.g., social support from family, friends and teachers) mediators were the most commonly examined mediators of physical activity behaviour, with a lack of studies investigating environmental mediating variables [82]. On review of these studies,

there is strong evidence for the mediating effects of self-efficacy and moderate evidence for intention as a mediator of behaviour change; however, the majority of the studies were conducted in secondary schools. Overall, the poor quality of a large number of studies and the lack of studies conducted in the primary school setting makes it difficult to draw conclusions regarding mediators of physical activity behaviour change in children [82].

Since publication of the updated systematic review, three studies have investigated the mediators of physical activity behaviour change in school-based interventions. The hypothesised mediators of physical activity behaviour change in the primary school-based Fit-4-Fun group randomised controlled trial were explored [83]. The study found that social support from teachers mediated physical activity behaviour change in primary school-aged children, whereas, self-efficacy, enjoyment, social support from peers and family, and the school environment did not satisfy the criteria for mediation [83]. No significant psychological and environmental mediators were found in the Dutch JUMP-In physical activity intervention for primary-school children [84]. Further, interpersonal (social support from teachers) and environmental (perceived school environment, accessibility of sports equipment and availability of line markings) mediators of recess and lunchtime physical activity in the primary school-based Transform-Us cluster randomised controlled trial were explored, however no significant mediating effects were observed [85]. The lack of significant mediation effects may be due to a number of reasons: i) the self-reported measurement of mediators, which is subject to socially desirable response bias, and the potential low sensitivity to change; ii) low reliability of some of the mediator measures; iii) intervention strategies not adequately implemented or may not be the most appropriate for changing the potential mediators; and iv) other potential mediators that may explain children's physical activity were not assessed [83-85].

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 behaviour change in children [81, 82]. Of note, only two studies in the primary school setting [83, 85] have examined the impact of hypothesised 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 [86]. Moreover, there is a distinct lack of studies investigating environmental mediating variables [82], which is surprising given the strong evidence for physical environmental variables as correlates of children's physical activity [78], and the importance of the physical environment as noted in health behaviour change models [87, 88]. High quality studies investigating the potential physical, psychological, social and physical environmental mediators of successful interventions are needed. This will enable strong recommendations for improving the effectiveness of physical activity interventions by targeting evidence-based mediators.

1.2.3. Theories of health behaviour

Theories of health behaviour combine important variables to provide a framework for explaining and changing behaviour [89]. There is an increased need for interventions targeting children to be framed by credible theories of health behaviour, as theoretical driven interventions are found to be more effective compared to non-theoretical interventions [90, 91]. Individual-level theories however, (e.g., health belief model), have been criticised, with theories that recognise the importance of the social and physical environment for behaviour change (e.g., socio-ecological model) gaining more support in the literature [89].

1.2.3.1. Socio-ecological model

The socio-ecological model of health behaviour acknowledges the multiple levels of influence on physical activity. The model focuses attention on both individual and social environmental factors as targets for health promotion [87]. Within the model, behaviour is viewed as being determined by intrapersonal (including characteristics of the individual such as knowledge, attitudes, behaviour, self-concept, and skills), interpersonal (including social networks such as family, peers, and teachers), organisational (including social institutions with organisational characteristics such as schools), community (including relationships among organisations), and public policy (including local, state, and national policies) factors (Figure 1.3). In the physical activity domain, the socio-ecological model also includes the built

environment [88]. The model guides intervention design to direct strategies at changing intrapersonal, interpersonal, organisational, community, and public policy factors to support and maintain health behaviours [87].

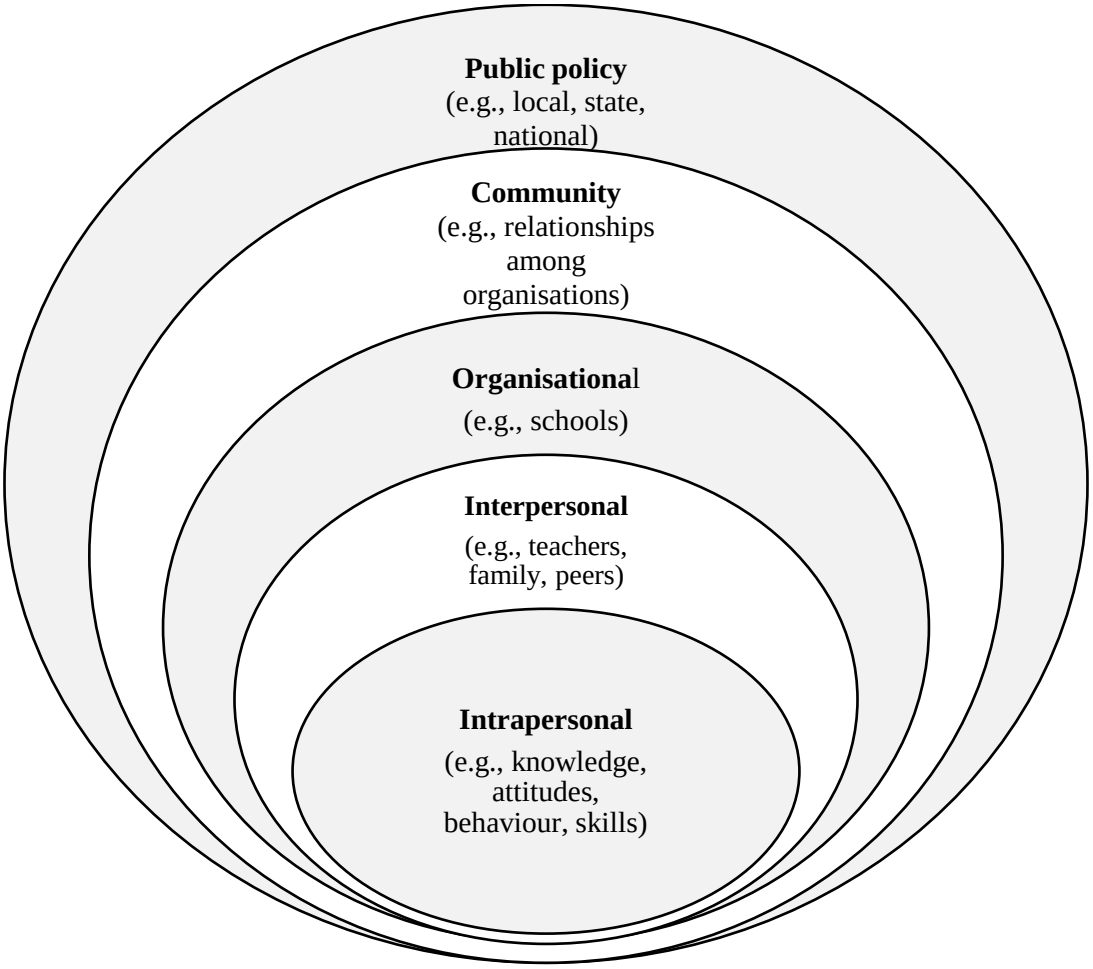

Figure 1.3 Levels of influence in the socio-ecological model [87]

As ecological models typically lack specificity at each level, other health behaviour models or theories can be integrated to enhance the specificity of treatment of each level [92]. The following two behaviour change theories target the intrapersonal level of the social-ecological model and were selected due their utility for explaining physical activity behaviour in children [93, 94] and constructs underpinning these theories being associated with physical activity behaviour in children [51, 72].

1.2.3.2. Self-determination theory

Self-determination theory (SDT) provides a model for human motivation [95, 96]. It suggests that people are driven by the innate psychological need to grow and gain fulfilment. The theory suggests that self-determined forms of motivation will be achieved by satisfying three basic psychological needs: 1) autonomy (i.e., the need to feel one's behaviours as self-endorsed and volitional); 2) competence (i.e., the need to effectively interact in one's environment and gain mastery of tasks and skills); and 3) relatedness (i.e., the need to feel supported and experience a sense of belonging) (Figure 1.4). It is proposed that social-contextual factors, such as those by teachers and parents, which allow individuals to satisfy these three needs, can promote self-determined motivation and subsequent behaviour [95, 96].

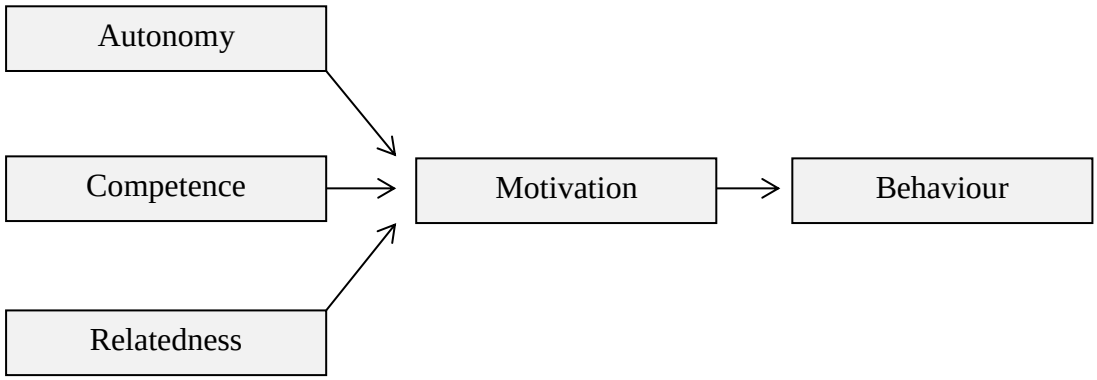

Figure 1.4 Self-determination theory [95]

SDT considers motivation in terms of its quality rather than quantity (i.e. amount) [96]. The theory categorises motivation as intrinsic (i.e., performing a behaviour for inherent satisfaction) or extrinsic (i.e., performing a behaviour to satisfy an external demand), with amotivation being the lack of intention or willingness to engage in a behaviour. At the far left hand end of the self-determination continuum (Figure 1.5) is non-self-determined behaviour and where amotivation is situated. Amotivation represents a lack of both extrinsic and intrinsic motivation and therefore, a complete lack of self-determination in regard to the target behaviour. Individuals are likely to be amotivated when they lack self-efficacy or control over the desired outcome, that is, when an individual in unable to regulate their behaviour [96].

Behaviour	Non-self-determined					Self-determined
Type of Motivation	Amotivation	Extrinsic Motivation				Intrinsic Motivation
Type of Regulation	Non-regulation	External Regulation	Introjected Regulation	Identified Regulation	Integrated Regulation	Intrinsic Regulation
Locus of Causality	Impersonal	External	Somewhat External	Somewhat Internal	Internal	Internal

Figure 1.5 The self-determination continuum [96]

Extrinsic motivation is situated in the centre of the continuum and represents outcomes of an ongoing individual-environment interaction [96]. It is anchored by controlled (i.e., external perceived locus of causality) and autonomous (i.e., internal perceived locus of causality) regulation. Controlled regulation is regarded low quality and deemed to have limited positive effects on behaviour, as behaviour is considered controlled, pressured or not self-determined. In contrast, autonomous regulation, while being extrinsically motivated, allows an individual to consider their behaviour self-determined (i.e., aligns with personal values, goals or sense of self), and is therefore of higher quality. At the far right hand end of the continuum is intrinsic motivation. Intrinsic motivation is associated with an internal perceived locus of causality and the prototype of self-determined activity. It is considered the highest quality motivation, and therefore predicated to have the strongest effect on behaviour [96].

1.2.3.3. Competence motivation theory

Competence motivation theory focuses attention on the factors that motivate individuals to participate in physical activity [97]. In this theory, self-esteem is identified as the key factor for physical activity behaviour. Within the theory, perceived competence and social support represent determinants of self-esteem, and enjoyment and physical activity behaviour are outcomes of self-esteem. It is proposed that targeting the determinants of self-esteem (i.e., perceived competence and social support from significant others in children's lives) will increase children's self-esteem and consequently increase the outcomes (i.e., directly impact physical

activity behaviour, or increase enjoyment and resultant physical activity behaviour) (Figure 1.6) [97].

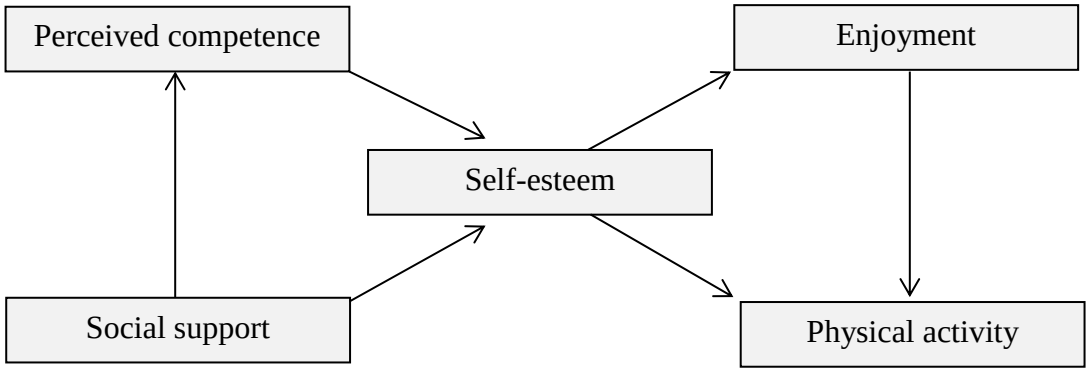

Figure 1.6 Competence Motivation Theory model (Harter's (1987) model of global self-worth customised for the physical domain [97])

1.2.3.4. Summary

Theories of health behaviour are used to explain why individuals engage in physical activity, and assist to change behaviour by guiding intervention design, delivery and evaluation. It is suggested that theories which target the key determinants of physical activity behaviour at multiple levels (i.e., individual, social and environmental) are the most powerful approaches to achieve sustainable behaviour change [89]. Although, theoretically driven interventions are found to be more effective [90, 91], theory alone cannot lead to effective interventions. Theory must be turned into effective interventions through planning of appropriate intervention components, and these must be applied with fidelity and evaluated in rigorous trials [89].

1.3. Physical activity interventions for children

The development of feasible and effective physical activity interventions for children has been identified as an important public health priority [98]. Determining and targeting the settings that will be the most effective for physical activity interventions for children is essential. A number of settings have been used to facilitate physical activity interventions among children, such as the home and/or family, community, after-school settings and gym/fitness/sports centre. However, the authors of recent reviews and meta-analyses have concluded that there is limited evidence supporting the utility of these settings for increasing physical activity in children [99, 100]. In contrast, there is evidence that multi-component interventions conducted in schools can increase physical activity in young people [101-103].

1.3.1. School-based physical activity interventions for children

Schools are ideally placed for the implementation of physical activity interventions. Children spend a large proportion (approximately 40–45%) of their day within the school setting [101]. Schools have the necessary facilities, equipment, personnel and curriculum to promote and provide opportunities for the development of healthy behaviours [102, 103]. The school setting provides a distinctive context for learning, when receptiveness and opportunity for attitudinal and behavioural change is possibly at its highest [101]. Furthermore, the government school system provides a rare setting where the full socio-economic range of the population can be reached and health inequalities can be addressed [101, 102].

Numerous school-based interventions aimed to increase children's physical activity have been designed and implemented [99, 104-107]. A recent Cochrane review concluded that school-based physical activity interventions can increase young people's MVPA by five to 45 minutes per week [107]. The evidence suggests that effective interventions were of longer duration, and included changes to the school curriculum, printed education materials, and likely, although there is less evidence to support, educational sessions, physical activity specific sessions and community-based approaches. To achieve sustainable effects, it has been suggested that interventions should involve the community, parents and engage multiple

environments that support an active lifestyle in children [107]. Kriemler and colleagues [106] also noted the potential efficacy of multi-component interventions that included family components.

Although school-based interventions can increase children's physical activity, a number of study limitations have been identified in recent reviews. For example, Dobbins and colleagues [107] noted that effect sizes were generally small, few interventions were theoretically driven, there was poor reporting of intervention fidelity, and a moderate risk of bias was identified (i.e., lack of blinding, consistency in outcome measurement, randomisation procedures, controlling for cofounders, and incomplete outcome data). Similarly, Kriemler and colleagues [106] described lack of blinding, poor description of randomisation procedures, and failure to adjust analyses for clustering and relevant confounders as limitations. Moreover, a major limitation noted in the reviews was the assessment of physical activity using self-report measures [106, 107]. Further, it was recommended that research is needed to evaluate the impact of physical activity interventions that take into consideration the known barriers and facilitators of physical activity behaviour among children, particularly among those from various SES backgrounds and different ethnic groups [107].

Due to the limitations associated with self-reported physical activity, Metcalf and colleagues [99] conducted a review of the effectiveness of physical activity interventions among children with objectively measured physical activity outcomes. The review found that physical activity interventions have limited effect on children's physical activity, with the pooled intervention effects across all studies being small to negligible for total physical activity (standardised mean difference 0.12; 95% CI 0.04 to 0.20) and small for MVPA (0.16; 0.08 to 0.24). A total of 30 studies were included in the review, 17 of which were school-based, 10 home/family-based and three conducted in community settings. Although intervention effects favoured school-based interventions, there were no statistically significant differences between settings. The authors suggested that the limited effects could be attributed to insufficient intervention design and dose, or components were not targeted to the appropriate environment or time period.

Furthermore, poor delivery of the intervention and poor uptake of the intervention components were also identified as contributing factors. In addition, the limited effects could be attributed to intervention specific physical activity sessions merely replacing a period of time of equally intense activity that children typically engage in (i.e., the ActivityStat hypothesis) [99]. Although, limited evidence has been found for the effectiveness of interventions to increase physical activity levels, the authors acknowledged the importance of physical activity interventions for skill development, self-confidence, and social inclusivity [99], all of which may be essential for future engagement in physical activity.

The maintenance of positive physical activity behaviours across childhood is vital, considering the age-related decline in physical activity as children progress into adolescents [108-110]. A recent review investigated whether children who participated in school-based physical activity interventions have sustained physical activity outcomes [111]. The review concluded that physical activity is a sustainable outcome from school-based interventions in children, with an average difference between intervention and control groups of up to 14 minutes per day [111]. Similarly, the recent Cochrane review found some evidence for positive physical activity intervention effects in children being maintained in the long-term [107]. Evidence exists for school-based interventions of at least one year in duration and that used a theoretical model or framework to guide the intervention being effective in produced sustained effects [111]. Furthermore, the review found good evidence for FMS being a sustainable outcome if developed in childhood [111]. This is an important finding considering the significant physiological, psychological, and behavioural health benefits associated with FMS competency [51]. Both reviews noted the small number of studies that had investigated the sustained effect of interventions and the need for additional research to strengthen the evidence base [107, 111].

In summary, school-based interventions can increase physical activity in children, yet study quality has been low and the effect sizes for objectively measured physical activity have been small [99, 106, 107]. Possible explanations for the weak findings include: the lack of theory driven interventions, the failure to address the multiple

components that influence behaviour within and beyond the school setting, and methodological weaknesses. There is clearly a need for more high quality studies, evaluating theoretically framed, multi-component interventions, which use an objective measure of physical activity, in order to provide strong recommendations for effective practice and policy in school-based physical activity promotion [99, 106, 107].

1.3.1.1. School-based physical activity interventions for children from low-SES communities

Children from low-SES backgrounds are less likely to meet physical activity guidelines in comparison to young people from middle- and high-SES backgrounds [13, 15-17, 19]. Physical activity interventions delivered in the school setting may assist in reducing the inequalities among low-SES populations in childhood, which has implications for their long-term health (i.e., adulthood) [112]. A number of studies have aimed to address this inequality through implementing school-based interventions in low-SES populations, with the majority of studies being conducted in secondary schools [113-120]. Findings from the limited studies conducted in primary schools [112, 121-123] give promise to the effectiveness of school-based interventions to increase physical activity among children living in low-SES communities.

The CATCH program was disseminated in primary (i.e., elementary) schools from low-income communities in El Paso, United States [121]. The program included a combination of curriculum and home-based strategies. The intervention resulted in significant increases in MVPA and vigorous physical activity at the end of the first year; however, these results were not maintained by the end of the second year in the program. Although, school recognition through the provision of rewards emerged as a powerful motivator in the program, it was recommended that the development of a school and community committee to support the implementation of the program, and professional learning opportunities for the personnel responsible for delivering the program was needed to maintain intervention effects over time [121]. JUMP-In was a primary school-based intervention for disadvantaged communities in the Netherland which combined environmental policy, personal, parent and community

components [122]. A significant beneficial intervention effect was found on organised sports participation, however not for overall daily physical activity. This finding provides evidence for the capacity of school-based interventions to influence children's physical activity engagement beyond the school-setting. However, some methodological limitations should be noted, including the non-random quasi-experimental study design, use of non-validated instruments for some measures, and an objective measure of physical activity was used in only a very small portion (i.e., 12%) of the sample [122].

Significant effects were achieved for objectively measured light, moderate and vigorous physical activity in the Sport for LIFE intervention which was implemented in socially disadvantaged communities [123]. The Sport for LIFE intervention was a 12-week primary school-based intervention based on social cognitive theory, which involved an in-school weekly program delivered by sports outreach officers in partnership with the classroom teacher, a teacher resource pack and homework tasks, providing further evidence for the effectiveness of a combination of school and home strategies. Of note, physical activity was measured objectively in only a subsample of children (n=84; 20% of the total sample) [123]. The APPLE Schools intervention provided evidence for the capacity of multi-level school-based interventions to reduce inequalities in physical activity [112]. The intervention increased objectively measured physical activity levels of children located in disadvantaged communities to the extent that they approximated those children located in higher SES communities [112]. The intervention was based on the Comprehensive School Health framework which included strategies targeting the social and physical environments, teaching and learning, school policy, and partnerships and services [112].

School-based interventions have the potential to reduce inequalities in physical activity. Evidence exists for theoretically framed, school-based interventions, involving home, community and policy strategies to increase physical activity in children from low-SES populations. Although evidence exists for the effectiveness of physical activity interventions in this population group, studies have not reported their effect on FMS competency. This is a notable exclusion as FMS competency

may serve as a protective factor against the decline in physical activity [52, 124]. Moreover, a limitation of previous school-based interventions is the poor reporting of intervention fidelity [106, 107]. Conducting process evaluation is essential to completely understanding the effects of an intervention and facilitates future translation [125, 126].

1.3.1.2. The role of teachers in school-based physical activity interventions

Teachers play a key role in schools to promote physical activity among children [127, 128]. Indeed, the success and sustainability of school-based interventions are largely dependent upon the degree to which teachers implement, and continue to implement the intervention strategies as intended [129, 130]. Specifically, classroom teachers spend more face-to-face time with children than any other teacher, and engage with children in a variety of other contexts within the school such as recess, lunchtime, extracurricular activities and before or after-school programs. Classroom teachers are appropriately situated to provide a number of physical activity opportunities for children and to be physical activity promotors within the school environment [102, 131].

Physical education (PE) is considered to be the primary vehicle for physical activity promotion within the school setting [132, 133] and high quality PE can have a positive effect on children's physical, affective, social, and cognitive outcomes [134, 135]. The quality, not just the quantity, of PE has been identified as a key determining factor in attaining the many health benefits [135]. Classroom or generalist teachers often deliver primary school PE in a number of countries. However, the quality of programs and instruction is of concern. Classroom teachers commonly include inappropriate lesson content, such as full-sided games, and lessons are delivered infrequently [136, 137]. Moreover, lessons often do not meet indicators of quality PE (i.e., 50% of PE time spent in MVPA [138]), with children only spending 45% (95% CI, 28.2-61.4) of PE lessons engaged in MVPA [139]. Not meeting this indicator of quality PE is of concern, as maximising practice opportunities is crucial in developing children's movement competencies [140].

Classroom teachers have reported facing a range of barriers that inhibit their ability to regularly deliver high quality PE. These include a lack of training, knowledge, confidence, interest and quality programs, as well as a crowded curriculum, little accountability, and limited space and facilities [141]. It is important for classroom teachers to have the ability to collaboratively and effectively plan, implement, and evaluate PE and physical activity programs in their classrooms and within the wider school environment. Continued education for classroom teachers has been identified as a key strategy for improving the quality of PE and the implementation of physical activity programs in the primary school setting [142]. It is recommended that teacher professional learning should address the barriers that classroom teachers face, as well as provide teachers with strategies to maximise FMS practice opportunities and MVPA during lessons [143]. There is a need for future school-based interventions to prioritise teacher professional learning to develop competent and confident classroom teachers and ensure all children receive quality learning experiences.

1.4. Chapter 1 summary

Many Australian children are insufficiently active to accrue the associated health benefits. Physical activity levels are also consistently lower among children of low-SES than children of middle- and high-SES. Physical activity levels decline dramatically during adolescence and evidence suggests that competency in a range of FMS may serve as a protective factor against this trend. Schools offer an ideal setting to promote physical activity and increase FMS competency in children. However, previous school-based interventions have had small effects on increasing children's physical activity, which may be attributed to the lack of a theoretical framework for guiding behaviour change, failure to address the multiple components that influence physical activity behaviour in and beyond the school setting, and methodological weaknesses. Currently, an evidence gap exists for effective, theoretically framed, multi-component school-based physical activity and FMS interventions for children located in low-income communities. Therefore, the aims of this thesis addressed the utility of FMS for promoting physical activity in children and the effectiveness of FMS interventions, and the development and evaluation of a primary school-based physical activity and FMS intervention for children living in low-SES communities.

1.5. Research aims

1.5.1. Primary aim

The primary aim of this thesis was:

1. To evaluate the impact of the Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES) intervention on MVPA, cardiorespiratory fitness and FMS competency among children attending primary schools located in low-income communities.

1.5.1.1. Thesis hypothesis

The primary hypothesis for this thesis is that children who receive the SCORES intervention will demonstrate significant improvements in MVPA, cardiorespiratory fitness and FMS competency, compared to children in a control group who will receive usual practice.

1.5.2. Secondary aims

This thesis also examined the following secondary aims:

1. To systematically review the evidence of interventions designed to improve FMS competency in typically developing children and adolescents.

2. To examine the association between FMS competency and objectively measured MVPA during time periods of the day that represent key physical activity opportunities (i.e., lunchtime, recess and after-school) among children attending primary schools located in low-income communities.

3. To determine if changes in FMS competency and perceived competence mediate the effect of the SCORES intervention on MVPA and cardiorespiratory fitness among children attending primary schools located in low-income communities.

4. To determine if changes in individual, social and physical environmental constructs mediate the effect of the SCORES intervention on MVPA among children attending primary schools located in low-income communities.

1.6. Thesis structure

This thesis is presented as a series of six papers. To date, five of these papers have been published, and one is under review. The thesis structure is presented below.

1.6.1. Chapter 1: Introduction

In the first chapter, a rationale for promoting physical activity, cardiorespiratory fitness and FMS competency in children was provided. Influences on children's physical activity and school-based physical activity interventions for children were explored. The chapter concluded with the research aims and thesis structure.

1.6.2. Chapter 2: Fundamental movement skill interventions in youth: A systematic review and meta-analysis

In Chapter 2, the findings from a systematic review and meta-analysis of the effectiveness of interventions designed to improve FMS competency in typically developing children and adolescents are reported (*Secondary Aim 1*).

Previously published as:

Morgan, P.J., Barnett, L.M., Cliff, D.P., Okely, A, D., Scott, H.A., **Cohen, K.E.,** & Lubans, D. R. (2013). Effectiveness of interventions to improve fundamental movement skill proficiency in youth: a systematic review and meta-analysis. *Pediatrics*, 132(5): e1361–e1383. (IF 5.473)

1.6.3. Chapter 3: Rationale and study protocol for the Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES) cluster randomised controlled trial: A physical activity and fundamental movement skills intervention for primary schools in low-income communities

In Chapter 3, the rationale and methods for the SCORES cluster randomised controlled trial are described.

Previously published as:

Lubans, D. R., Morgan, P. J., **Weaver, K.,** Callister, R., Dewar, D. L., Costigan, S. A., Finn, T.L., Smith, J., Upton, L., & Plotnikoff, R.C. (2012). Rationale and study protocol for the SCORES group randomized controlled trial: A physical activity and fundamental movement skills intervention for primary schools in low-income communities. *BMC Public Health*, 12(1): 427-438. (IF 2.264)

1.6.4. Chapter 4: Fundamental movement skills and physical activity among children living in low-income communities: A cross-sectional study

In Chapter 4, the findings from a cross-sectional study examining the associations between FMS competency and objectively measured MVPA during time periods of the day that represent key physical activity opportunities for children (i.e., lunchtime, recess and after-school) are reported (*Secondary Aim 2*).

Previously published as:

Cohen, K.E., Morgan, P. J., Plotnikoff, R. C., Callister, R., & Lubans, D. R. (2014). Movement skills and physical activity among children living in low-income communities: a cross-sectional study. *International Journal of Behavioral Nutrition and Physical Activity*, 11(1): 49-57. (IF 4.111)

1.6.5. Chapter 5: Physical activity and skills intervention: SCORES cluster randomised controlled trial

In Chapter 5, the findings from the SCORES cluster randomised controlled trial are reported (*Primary Aim*).

Previously published as:

Cohen, K.E., Morgan, P. J., Plotnikoff, R. C., Callister, R., & Lubans, D. R. (2015). Physical activity and skills intervention: SCORES cluster randomized controlled trial. *Medicine and Science in Sports and Exercise*, 47(4): 765-774. (IF 4.475)

1.6.6. Chapter 6: Improvements in fundamental movement skill competency mediate the effect of the SCORES intervention on physical activity and cardiorespiratory fitness in children

In Chapter 6, the results from a mediation analysis conducted to determine if changes in FMS competency and perceived competence mediated the effect of the SCORES intervention on MVPA and cardiorespiratory fitness are reported (*Secondary Aim 3*).

Previously published as:

Cohen, K.E., Morgan, P. J., Plotnikoff, R. C., Barnett, L. M, & Lubans, D. R. (2015). Improvements in fundamental movement skill competency mediate the effect of the SCORES intervention on physical activity and cardiorespiratory fitness in children. *Journal of Sports Sciences*, 33(18): 1908-1918. (IF 2.246)

1.6.7. Chapter 7: Psychological, social and physical environmental mediators of the SCORES intervention on physical activity among children living in low-income communities

In Chapter 7, the results from a mediation analysis conducted to determine if changes in psychological, social and physical environmental constructs mediated then effect of the SCORES intervention on MVPA are reported (*Secondary Aim 4*).

The findings in this chapter are currently under review:

Cohen, K.E., Morgan, P. J., Plotnikoff, R. C., & Lubans, D. R. (under review). Psychological, social and physical environmental mediators of the SCORES intervention on physical activity among children living in low-income communities. *Journal of Behavioral Medicine*. (IF 2.959)

1.6.8. Chapter 8: Discussion

An overview and synthesis of the findings addressing the primary and secondary research aims are provided in the final chapter of the thesis. The future research and practice recommendations based on the findings are provided. Furthermore, the significance and future directions of SCORES and the study conclusions are presented.

CHAPTER 2. FUNDAMENTAL MOVEMENT SKILL INTERVENTIONS IN YOUTH: A SYSTEMATIC REVIEW AND META-ANALYSIS

Preface:

This chapter presents the results of a systematic review and meta-analysis, which was conducted to investigate *Secondary Aim 1* of this thesis (i.e., to systematically review the evidence of interventions designed to improve FMS competency in typically developing children and adolescents).

The content in this chapter is the final version of the article which is published in the journal *Pediatrics*.

Citation:

Morgan, P.J., Barnett, L.M., Cliff, D.P., Okely, A, D., Scott, H.A., **Cohen, K.E.,** & Lubans, D. R. (2013). Effectiveness of interventions to improve fundamental movement skill proficiency in youth: a systematic review and meta-analysis. *Pediatrics*, 132(5): e1361–e1383.

Abstract

Background: Fundamental movement skill (FMS) proficiency is positively associated with physical activity and fitness levels. The objective of this study was to systematically review evidence for the benefits of FMS interventions targeting youth.

Methods: A search with no date restrictions was conducted across 7 databases. Studies included any school-, home-, or community-based intervention for typically developing youth with clear intent to improve FMS proficiency and that reported statistical analysis of FMS competence at both pre-intervention and at least 1 other post-intervention time point. Study designs included randomized controlled trials (RCTs) using experimental and quasi-experimental designs and single group pre-post trials. Risk of bias was independently assessed by 2 reviewers.

Results: Twenty-two articles (6 RCTs, 13 quasi-experimental trials, 3 pre-post trials) describing 19 interventions were included. All but 1 intervention were evaluated in primary/elementary schools. All studies reported significant intervention effects for ≥1 FMS. Meta-analyses revealed large effect sizes for overall gross motor proficiency (standardized mean difference [SMD] = 1.42, 95% confidence interval [CI] 0.68–2.16, Z = 3.77, P < .0002) and locomotor skill competency (SMD = 1.42, 95% CI 0.56–2.27, Z = 3.25, P = .001). A medium effect size for object control skill competency was observed (SMD = 0.63, 95% CI 0.28–0.98, Z = 3.53, P = .0004). Many studies scored poorly for risk of bias items.

Conclusions: School- and community-based programs that include developmentally appropriate FMS learning experiences delivered by physical education specialists or highly trained classroom teachers significantly improve FMS proficiency in youth.

2.1. Background

It is well established that physical activity is vitally important for the healthy growth and development of children [144], however, most children are not adequately active [9]. Physical activity not only provides an opportunity to expend energy but provides the medium for the development of fundamental movement skills (FMS). Gallahue and Donnelly [1] define a FMS as "an organized series of basic movements that involve the combination of movement patterns of two or more body segments" (p. 52). According to Gallahue, Ozman and Goodway [145] these movements are commonly categorised as locomotor (e.g., running, jumping, and hopping; p. 448) and object control or gross manipulative skills (e.g., catching, throwing, and kicking; p. 449) [145]. FMS are considered to be the foundation skills that lead to specialized movement sequences required for participation in many organized and non-organized physical activities for children and adolescents [146]. FMS are optimally developed in childhood and then refined into context and sport-specific skills [146]. For instance, throwing can be refined to 'pitching' in baseball or a 'serve' in tennis. FMS mastery or motor competence is more likely to be achieved with quality instruction and practice [145], while children who are not provided with opportunities to develop skills may demonstrate developmental delays in their gross motor ability [147, 148].

Children's FMS proficiency is low in a number of countries [149-151], with many entering adolescence having not mastered these basic movement skills [150]. This is a particular concern, as a recent systematic review of the health benefits of FMS proficiency found consistent and positive associations between FMS proficiency and physical activity and fitness levels, and an inverse association with weight status [152]. There is also longitudinal evidence that motor skills track through childhood [153, 154] and into adolescence [155, 156]. FMS proficiency has been associated with subsequent physical activity [157] and also with change in physical activity over time, highlighting that children with high FMS proficiency show little decline in physical activity [158]. In addition, positive associations have been established between FMS proficiency and objectively measured physical activity in overweight children [159].

Efforts to promote physical activity in youth would benefit from a greater understanding of evidence-based strategies to improve FMS proficiency. Recommendations for school- and community-based physical activity programs from various countries have FMS development as an integral aspect of physical education and school and community sport [160-162]. However, little is known about the efficacy of interventions designed to improve FMS proficiency in typically developing children and adolescents. Reithmuller, Jones and Okely [163] conducted a systematic review of controlled trials on the efficacy of motor development interventions in young children (<5 years old) and reported the evidence base was limited in both quality and quantity. Another recent review and meta-analysis included both typically developing and non-typically developing children, but only included studies which used a qualitative FMS assessment (with only one instrument meeting inclusion criteria) [164]. Another limitation recognized in this review was that most studies in the meta-analysis included children that were developmentally delayed and/or of preschool age.

Therefore, the aim of this current review was to conduct a systematic review and meta-analysis of the effectiveness of interventions designed to improve FMS proficiency in typically developing children and adolescents using both process- and product-oriented FMS assessment and including both randomised and non-randomised trials.

2.2. Methods

The conduct and reporting of this review adhered to the guidelines outlined in the *Preferred Reporting Items for Systematic Reviews and Meta-analysis* (PRISMA) Statement [165].

2.2.1. Eligibility criteria

2.2.1.1. Types of participants

Children enrolled in primary/elementary, middle or high school. The age range of children in these different levels of schooling may vary by country but in general covers the ages: primary/elementary (5-12yrs); middle (12-14yrs), high (12-18yrs or 14-18yrs in areas with middle schools) school. Studies targeting overweight/obese

children or children from schools in disadvantaged areas were included but not those where participants had developmental coordination delays (i.e. where study inclusion criteria specified these characteristics).

2.2.1.2. Types of interventions

Any school-, home- or community-based intervention for children and adolescents with clear intent to improve FMS proficiency.

2.2.1.3. Types of outcome measures

Studies were included if they reported statistical analyses of FMS competence at both pre-intervention and a minimum of one other post-study time point. There must have been process (i.e., technique) or product (i.e., outcome) assessment of at least one of the following: run, vertical jump, horizontal jump, hop, dodge, leap, gallop, side gallop (slide), skip, roll, throw (under- or over arm), stationary dribble, catch, kick, two-handed strike, forehand strike, static balance, or categorised in groups of commonly described similar skills such as locomotor or object-control skills, or global FMS score [166].

2.2.1.4. Types of studies

Study designs included randomized controlled trials (RCTs) using experimental and quasi-experimental designs and single group pre-post trials.

Studies were excluded if they met any of the following criteria: (i) participants were targeted groups from special populations (e.g. children with disabilities such as cerebral palsy or identified as having developmental coordination disorder or conditions such as mental illness); (ii) not published in English; (iii) used measurement batteries that incorporated an assessment of fine motor skills, motor coordination, motor ability or fitness or that included a focus on a skill unique to a particular sport; (iv) participants were children who were enrolled in preschools or child care centers.

2.2.2. Information sources and search

Studies were identified by searching electronic databases and scanning reference lists of included articles. Seven electronic databases were searched: Medline [Ovid], EMBASE, PsychInfo, SCOPUS Current Contents Connect, Sports Discus, ERIC [Ovid] and Informit. No publication date restrictions were imposed in any database and the last search was completed in June 2013. Search terms were divided into three groups: (i) population (e.g., children OR child* OR youth* OR adolescent OR school OR primary OR elementary OR high OR secondary); (ii) study design: (e.g., random* OR clinic* OR trial OR intervention OR evaluation OR experiment OR program* OR pilot OR feasibility); (iii) Intervention type: (e.g., physical activity OR exercise OR motor skill OR movement skill OR fundamental motor skill OR fundamental movement skill OR coordination OR motor development). The Boolean phrase 'AND' was used between groups and the phrase 'OR' was used within groups.

2.2.3. Study selection

Following the search, one of the authors (HAS) removed all duplicates and screened the title and abstract of remaining records in a non-blinded standardized manner. Only articles published or accepted for publication in refereed journals were considered. A second author (PJM) checked all decisions and any disagreements were resolved by discussion. If there was not sufficient information available to make a decision, the article was retrieved for clarification. Consensus was reached by discussion when disagreement arose. Full text articles were then retrieved for all remaining records. Two authors (PJM and LMB) independently screened these articles for inclusion with a 'yes, no or maybe' approach. Following this, both reviewers conferred and after discussion full consensus was reached on all articles. The reference list of each included study was searched for additional studies.

2.2.4. Data collection process

One author (KW) extracted study data relating to methodology, participant characteristics, intervention description, FMS measure and the intervention effect on FMS. Another reviewer (DRL) checked the extracted data.

2.2.5. Risk of bias in individual studies

Risk of bias was independently assessed by two reviewers (DPC and ADO) using a 9-item tool adapted from the Consolidated Standards of Reporting Trials (CONSORT) statement [167] and previously used quality criteria [168] (see Table 2.1). As recommended in the PRISMA statement, these items were not numerically summarised to give a final score, rather each criteria was considered in isolation [169]. In accordance with empirical evidence, criterion A, C, D and H were regarded as the most significant items in which bias could have an impact on results [169, 170]. Each item on the scale was coded as 'explicitly described and present' (✓), 'absent' (×) or 'unclear or inadequately described' (?). Inter-rater reliability for the assessors was calculated on a dichotomous scale (✓=1 vs. × or ?=0) using percentage agreement and Cohen's κ. Depending on the study design, some items were coded as not applicable (N/A) and not included in agreement calculations. Disagreements between assessors were resolved by discussion.

Table 2.1 Risk of bias checklist

Item	Description
A	Randomization (generation of allocation sequence, allocation concealment and implementation) clearly described and adequately completed
B	Valid measures of FMS proficiency used (validation in same age group has been published or validation data was provided by the author)
C	Blinded outcome assessment (positive when those responsible for assessing FMS proficiency were blinded to group allocation of individual participants)
D	Participants analysed in group they were originally allocated to, and participants not excluded from analyses because of non-compliance to treatment or because of some missing data
E	Covariates accounted for in analyses (e.g. baseline score, group/cluster for cluster RCTs, and other relevant covariates where appropriate such as age or sex)
F	Power calculation reported for primary FMS outcome
G	Presentation of baseline characteristics separately for treatment groups (age + sex + at least one FMS outcome measure)
H	Dropout for FMS measure described, with a ≤ 20% dropout for studies with follow-up of ≤ 6-months and ≤ 30% dropout for studies with follow-up > 6-months
I	Summary results for each group + estimated effect size (difference between groups) + its precision (e.g. 95% confidence interval)

2.2.6. Synthesis of results

Data were first collated and described in a narrative summary with emphasis given to results from RCTs. Meta-analyses were conducted for studies that provided composite scores (i.e., 2 or more skills combined) for overall FMS proficiency, locomotor and object control proficiency using RevMan version 5.1 [171]. Studies that included a control or comparison group and reported baseline and post-test values or change scores, along with measures of distribution (i.e., standard deviation or confidence intervals) were included in the meta-analyses. When studies compared multiple treatment groups with a single control group (n = 2), the sample size of the control group was divided to avoid double counting. For studies that included post-test and follow-up assessments, the assessments completed at the end of the intervention period (i.e. post-test) were included in the meta-analysis. As FMS proficiency was assessed using a range of instruments, the standardised mean difference (SMD) with 95% confidence intervals was reported. Estimates were obtained using the DerSimonian-Laird [172] random effects estimator and studies were weighted by the inverse of their variance. Statistical heterogeneity was examined via Chi-square and the I^2-Index tests. The standardised effect sizes were interpreted as small (0.3), medium (0.5) and large (0.8) [173].

2.3. Results

2.3.1. Overview of studies

The flow of studies through the review process and reasons for exclusion are displayed in Figure 2.1. The initial search identified 12,329 citations. After screening the titles and abstracts of potential studies, 59 full-text articles were retrieved. From this number, 22 studies (representing 19 unique interventions) were included.

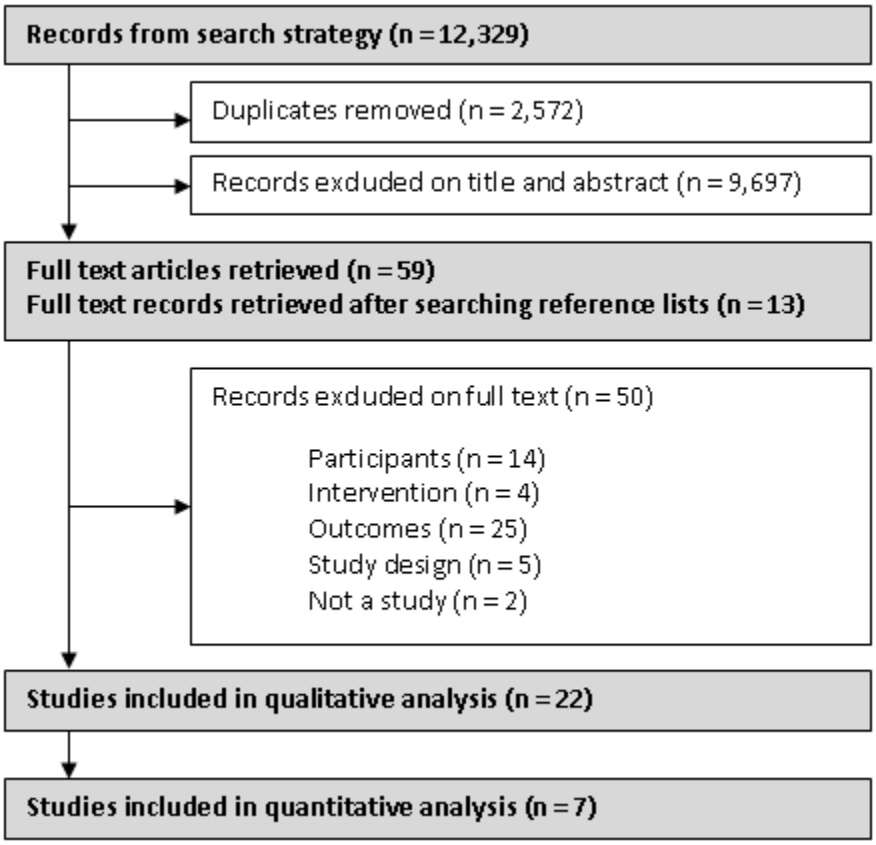

Figure 2.1 PRISMA flowchart of studies through the review process

2.3.2. Study characteristics

Table 2.2 displays selected characteristics of eligible studies including FMS results. Eight studies were published between 2010 and 2013 [174-181], 11 between 2000-2009 [182-192], two between 1990 and 1999 [193, 194] and one in 1989 [195]. The majority of studies were conducted in the United States of America [175, 178, 188, 193-195], Australia [176, 183, 189, 191, 192] and Sweden [177, 184, 185, 190]. The majority of interventions were evaluated in primary/elementary schools among children with only one study in high school with adolescents [180]. Two studies were community-based interventions targeting overweight and obese children [176, 183]. One study included boys only [182], one girls only [174], and the remaining were co-educational.

There were six RCTs [174, 176, 186, 187, 189, 194] (including 3 cluster RCTs [186, 189, 194]), 13 quasi-experimental studies [175, 177-180, 182, 184, 185, 188, 190-193] and three single group pre-post studies [181, 183, 195]. Seven studies included follow-up assessments after a period of no intervention [176-178, 180, 183, 189, 192]. One study did not include an immediate post-intervention assessment after their 5-week intervention [185], but did include follow-up assessments at 1- and, 2- and 9-years post baseline. The sample sizes for the studies ranged from 13 [183] to 1464 [175] and 10 studies had a sample size of greater than 250 [175, 177, 180, 181, 184, 185, 189, 191, 192, 194].

2.3.3. Risk of bias within studies

Table 2.3 displays the risk of bias assessments for all studies. Inter-rater reliability metrics for the risk of bias assessments indicated substantial agreement for all 187 items (percentage agreement 95%, k = 0.84). Seventeen of the twenty-two studies used measures of FMS proficiency that had published validity [155, 174, 176-185, 187-190, 193], and this was the most commonly reported item across the studies. Nine studies met the criteria for adequate retention [174, 175, 177, 178, 183, 188, 190, 193, 194]. Assessor blinding was reported in three studies [175, 176, 189], while in six studies, participants were analyzed in their allocated group and were not excluded because of missing data or non-compliance [174, 176, 180, 183, 189, 193]. Of the six RCTs, the randomization procedure, including sequence generation, allocation concealment, and implementation, was adequately described in only one study [176]. None of the studies reported a power calculation for FMS outcomes.

2.3.4. Measurement of FMS

Studies used a combination of process and product measures to assess FMS competency. The Test of Gross Motor Development-2 was the most common measure of FMS and was used in nine studies [174, 176, 179, 181-183, 187, 188, 193]. The ‘Get Skilled Get Active’ measure was used to evaluate two interventions [186, 191]. Matvienko et al.[178] and McKenzie et al. [194] developed product measures designed to assess children’s catching, kicking distance and throwing accuracy.

2.3.5. Types of interventions

Nearly all interventions were delivered in the primary school setting with four conducted after school [176, 178, 183, 186] and one in high school [180]. Most interventions were delivered by physical education (PE) teachers [175, 176, 178-180, 183, 184, 187-190, 194, 195], or experienced coaches [186], with some using trained classroom teachers [194] or trained pre-service teachers [191, 193] or PE specialists to help classroom teachers [181, 190]. Interventions ranged in duration from 4-weeks [178] to 3-years [190, 194]. On average, interventions offered between 8 and 195 hours of instruction and ran for 12 weeks (median). Many of the interventions followed a structured format and included a prescribed number of lessons per week, although a number did not provide detailed intervention descriptions (e.g. [174, 182, 186, 193]).

Some of the interventions had a greater focus on providing teacher professional development (e.g. [180, 194]) or additional support to teachers (e.g. [181, 191]). These interventions tended to be longer in duration, and often included multiple strategies and intensive support for teachers [189, 191, 192, 194]. For example, the Move It Groove It intervention [191, 192] involved a whole school approach, which included school project teams, a buddy program with pre-service teachers, professional development (5 days of training and 4 workshops) and a project website. Similarly, for the trained classroom teacher study arm in the SPARK intervention [194], teachers received 32 hours training in year 1, 9 hours in year 2, and also received onsite support by a PE specialist (biweekly to bimonthly) that included observations, modeling, feedback, and other assistance.

2.3.6. Theoretical frameworks or pedagogical approach guiding the interventions

A number of the PE-based interventions tested an ‘enhanced’ PE curriculum with a focus on optimal FMS development versus traditional PE [175, 180, 187, 188] or free play [193], while some compared both enhanced PE and additional time spent in PE [179, 185, 189, 191, 194] or simply evaluated the benefit of an increased time allotment for PE [190]. Many of the interventions did not provide detail about the theoretical or pedagogical approach that the intervention was based on. Some were

based on one approach, while others used a combination of approaches. The following approaches were described: mastery motivational climate [183, 187, 188], competence motivation theory [176, 183], hypothetic-deductive [185], self-learning [186], and movement exploration and self-testing [187, 195]. Martin and colleagues [188] utilized a mastery motivational climate that allowed students to move freely throughout FMS stations and were encouraged to self-regulate the time spent at each station, the level of task difficulty, and their grouping. Most other interventions were based on direct instruction (teacher-led activities, games) or not described.

2.3.7. Evidence for FMS outcomes

All studies reported statistically significant intervention effects for one or more FMS. Ten studies reported significant group-by-time effects for overall motor skill competency [174, 176, 180-182, 184, 187, 190, 191, 193] and one study found improvements in girls only [189]. Alternatively, McKenzie and colleagues [194] found that changes in total skill competency among students in the intervention groups were greater but not significantly different to those observed in the control group who continued with their usual PE programs.

Both short-term (i.e., 4-8 weeks) and long-term (> 6-months) interventions were successful in increasing FMS competency. Of those studies that reported results beyond post-intervention assessments [176-178, 180, 183, 189, 192], six reported positive intervention effects on at least one outcome [177, 178, 180, 183, 189, 192]. Both Barnett et al. [192] and Ericsson [177] reported significant long-term effects after 6- and 9-years respectively. Some studies reported their results separately for boys and girls or included sex as an interaction term/covariate in their analysis [176, 185, 189-191, 193-195]. Some found both boys and girls improved [185, 191, 193, 195], others reported boys made greater gains in the intervention [194] or control group [185] and one found the intervention favoured girls [189].

2.3.8. Meta-analysis of FMS intervention effects

Because there was considerable heterogeneity among interventions, the random effects models were used for all analyses. The meta-analyses revealed large effect sizes for overall gross motor proficiency (SMD = 1.42, 95% CI 0.68-2.16, Z = 3.77,

P < .0002; Figure 2.2) and locomotor skill competency (SMD = 1.42, 95% CI 0.56-2.27, Z = 3.25, *P* < .001; Figure 2.3). A medium effect size for object control skill competency was observed (SMD = 0.63, 95% CI 0.282-0.98, Z = 3.53, *P* < .0004; Figure 2.4). A funnel plot to assess publication bias was not produced as the meta-analyses included less than 10 interventions [196].

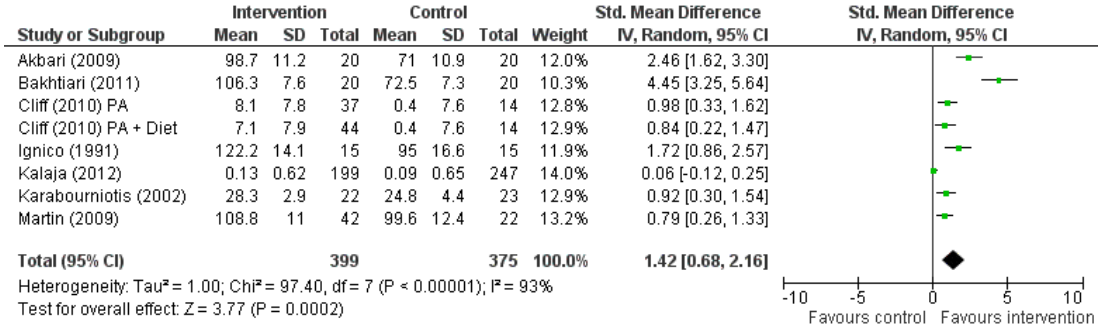

Figure 2.2 Meta-analysis comparing the effects of FMS interventions on overall gross motor skill proficiency

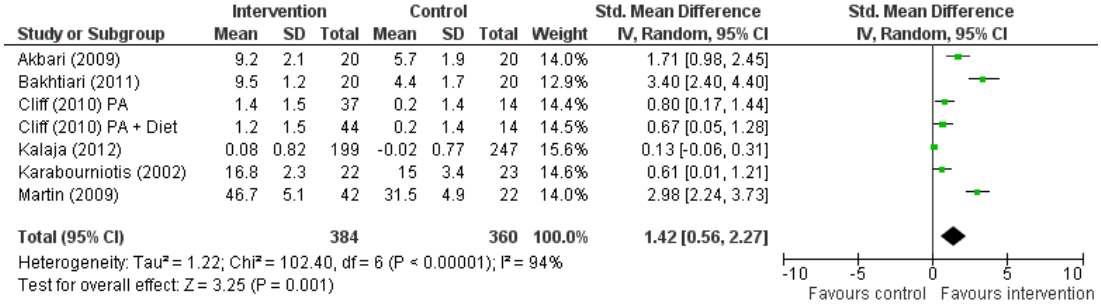

Figure 2.3 Meta-analysis comparing the effects of FMS interventions on locomotor skill proficiency

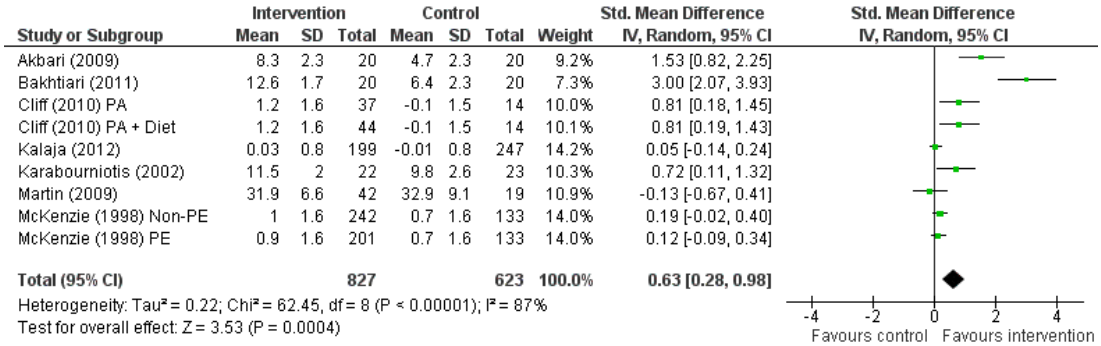

Figure 2.4 Meta-analysis comparing the effects of FMS interventions on object-control motor skill proficiency

2.4. Discussion

The aim of this systematic review was to synthesize the evidence on the effectiveness of FMS interventions among typically developing youth. Of the 22 eligible studies (including six RCTs), 19 unique interventions were evaluated with all reporting intervention effects for one or more FMS. Meta-analyses revealed statistically significant intervention effects for overall gross, locomotor and object control skill proficiency. While these findings are promising, there was a high risk of bias in many of the included studies.

The evaluation of FMS interventions is a relatively new area of research. Although the first study was conducted in 1989 [195], 86% have been published since 2000. There was considerable variation in both intervention design and duration, but most were delivered in the primary school setting by PE specialists. Only one study was conducted with adolescents, which is not surprising given that FMS are optimally developed and ideally targeted in childhood. However, the lack of studies is of concern, given the poor FMS proficiency of many children who are now entering high school [150, 151, 197] and this may be an important area for future work. Intervention effects for one or more FMS outcomes were reported in all studies, with 10 reporting significant effects for overall motor skill competence. In studies conducting follow-up assessments beyond the post-intervention assessment, six reported positive intervention effects, including two which had long-term follow-up [177, 192]. However, significant effects were not observed for all FMS measured.

The effect sizes found in the current review were large, and greater than those observed in a previous meta-analysis of FMS interventions in mostly younger children [164]. However, there were only a relatively small number of heterogeneous studies included in the meta-analyses. We found the effect size for locomotor skills was greater than for object control skills. This is in contrast to a recent meta-analysis by Logan et al., which found no difference. This disparity may be due to the different age groups sampled as Logan et al.'s meta-analysis included mostly studies of children with developmental delays or of preschool age. Our findings may suggest that object control skills are more difficult to improve than locomotor skills. This

may be due to the greater skill component complexity and perceptual demand of object control skills, which may require more intensive skill instruction and practice.

Although the findings are positive for FMS improvements, these results should be interpreted with some caution due to the high risk of bias identified and because less than one-third of studies were RCTs. The high risk of bias was similar to a recent review of FMS interventions in young children [163], although the number of studies demonstrating significant intervention effects was higher in the current review. In the current review, most studies used a valid FMS measure but no studies reported a power calculation for an FMS outcome. Moreover, studies scored poorly for risk of bias items that are most likely to bias the estimate of an intervention's effectiveness [169, 170], particularly for assessor blinding, participants being excluded because of missing data, retention, and poor descriptions of the randomisation process for the RCTs.

2.4.1. Evidence from RCTs

For all RCTs, the effect on FMS outcomes was in favour of the intervention group. The risk of bias was lower than the other studies but still quite high for two-thirds of studies. The RCTs evaluated five programs in the primary school [174, 187, 189, 194] or after school settings [186] in five different countries, and one study for overweight children in a community setting [176]. The school-based RCTs were conducted with generally small samples (<100) and differed slightly in terms of their FMS impact, with some reporting effects on overall motor competence (both locomotor and object control) [174, 187, 194], while others impacted on a select number of individual skills [186] or in a sub-group analysis favouring girls [189].

2.4.2. FMS intervention characteristics and pedagogical approaches employed

Many studies did not describe their intervention sessions or teaching strategies in detail (e.g. [174, 179, 182, 186, 193]) and while intervention components varied across studies, they generally involved multiple lessons per week. Similar heterogeneity was also found in the review of young children [163]. A number of the PE-based interventions tested an 'enhanced' PE curriculum with a focus on optimal FMS development versus traditional PE [175, 180, 187, 188] or free play [193],

while some compared both enhanced PE and additional time spent in PE [179, 185, 189, 191, 194] or simply evaluated the benefit of an increased time allotment for PE [190].

Of those studies that compared enhanced PE (i.e. targeting FMS development) versus typical PE (e.g., games) [175, 180, 187, 188] or free play [193], findings demonstrated the benefits of pedagogical approaches that enabled the learner to experience autonomy, developmentally appropriate tasks, mastery and receive individualized feedback. This is of note, given that the control groups in these studies received the same time in PE or 'dose' as the intervention group and both intervention and control groups had PE specialists deliver the respective programs. For example, Karabourniotis et al. [187] demonstrated the benefits of a motor skill-focused program characterised by self-testing activities and many opportunities for individual practice, compared with usual PE lessons using a games approach. Martin et al. [188] showed greater gains in FMS proficiency of children in a mastery climate as compared with a low autonomy group, although as the intervention was delivered by the research team, it is possible that a teacher effect may have contributed to the group differences. However, a mastery climate, focusing on success, optimal challenge and autonomy, led to improvements in FMS in multiple other studies [180, 183, 187, 193], highlighting the benefits of this pedagogical approach. While research in PE pedagogy has demonstrated the value of direct instruction [198, 199], student-centred approaches where students are given choice may enhance intrinsic motivation [200], on-task behaviour, effort and FMS proficiency. However, more research is needed to determine optimal pedagogical approaches.

Other studies in our review compared the effects of additional teacher training and/or time for PE lessons [179, 185, 189-191, 194] with usual PE practice and demonstrated improved FMS outcomes. For example, McKenzie et al. [194] demonstrated that classroom teachers who received extensive training and ongoing support meaningfully impacted on their students' FMS. Ericsson [177, 184, 185] found superior FMS gains from a greater dose of PE (5 lessons per week) compared to the school's ordinary PE (2 lessons per week).

Given the issues identified in primary school PE internationally, including the constraints of a 'crowded curriculum' [201-204], further strategies to integrate FMS learning beyond the school may have merit. This was a successful strategy used in four studies in the after-school setting [176, 178, 183, 186] and by using supplementary home-based FMS tasks [176, 183, 194]. Matvienko et al. [178] found a short, intense after-school program produced significant and sustained FMS changes in the short-term. Few studies [176, 183, 184] reported using parents as part of the intervention, as also found in Reithmuller's [163] FMS review in young children. Given the limited PE curriculum time in primary schools, strategies to engage parents in both school-based lessons and to support practice opportunities outside of school may be a worthwhile target for future interventions.

Overall, it is difficult to ascertain which intervention characteristics were most important given the differences in design, program length and limited detail provided. Most studies did not detail the 'dose' received (e.g. attendance, FMS on-task time). Interestingly, the Logan et al. review [164] found no association between FMS effect size and intervention duration, likely due to a disparity between intervention length and dose, with most studies not reporting actual FMS on-task time (i.e. the actual time a child is engaged in an activity where they are practising or applying a FMS). This is an important area for future research, as motor skill development theory shows that a key factor is the number of correct practice trials a child completes [198].

In addition, a longer intervention may not result in better FMS outcomes because some children (particularly older) may experience a 'ceiling effect' with some FMS measures. Process-oriented assessment batteries distinguish well at the lower end of skill ability but not the higher end. As children grow and develop they are more likely to be proficient in a FMS, or even excel at it, but the child who 'excels' may score the same as a child who simply displays proficiency in the core skill components. Ceiling effects are less likely to occur with product assessments as there is always the possibility to perform better when the scoring is related to speed, distance or accuracy.

2.4.3. Implications and recommendations

Quality of instruction and time spent in practice are of utmost importance in improving FMS competence [145]. PE is a critical medium for providing this opportunity and is recognised as one of the most influential factors in FMS development [205]. Most of the school-based interventions targeted PE and PE specialists as facilitators. The interventions that used classroom teachers [181, 191, 192, 194] involved substantial professional development. As many countries employ classroom teachers to deliver primary school PE, it is critical that FMS lessons are delivered appropriately and frequently [206]. Many studies have confirmed the tendency of classroom teachers to deliver PE programs consisting of inappropriate lesson content including large-sided team games or free play [136, 207]. Therefore, schools should ensure FMS lessons are delivered in a pedagogically appropriate manner [201] and that PE specialists are engaged. Given the primary school years are considered the optimal time to develop FMS [145], and current issues with FMS learning contexts in primary schools [208], training and resources need to be prioritized so children can receive quality instruction. Researchers and education authorities may also need to consider the adoption of evidence-based programs and determine how these could be translated and sustained without researcher support.

Although risk of bias was quite high overall, it is possible that studies were inadequately reported rather than conducted, and thus may have underestimated actual study quality. Future research should utilise the CONSORT and Transparent Reporting of Evaluations with Nonrandomized Designs (TREND) statements. In particular, it is imperative that researchers report their interventions in greater detail (e.g. intensity, duration, fidelity, characteristics of facilitators/recipients) [209] . More evidence is needed to determine what program components are associated with enhanced FMS competence and the optimal dose, duration and intensity of interventions. In addition, as most of the studies only included assessments immediately following the intervention, future studies should include follow-up assessments beyond the post-intervention time point to determine any sustained or long-term effects. Further studies are needed that report results separately by sex, given established differences in FMS proficiency between boys and girls [150, 156]

and that findings from a few studies highlighted the need for increased attention on girls' FMS proficiency (e.g. [194]).

2.4.4. Strengths and limitations

This review had a number of strengths: (i) a comprehensive search strategy across multiple databases with no date restrictions; (ii) extensive study detail extracted and broad inclusion criteria; (iii) high agreement levels for risk of bias assessments, and; (iv) alignment with the PRISMA Statement [169]. Limitations included: (i) studies were required to be published in English; (ii) inclusion of a generally modest number of heterogeneous studies; (iii) inability to rule out publication bias; (iv) potential study comparison difficulties due to the different types of FMS measures used.

2.5. Conclusion

Given the established associations between FMS and a range of health-related benefits [152, 197], future research is needed to evaluate high quality trials with long-term follow-up. We found evidence for the positive influence of programs of enhanced PE to improve FMS proficiency of children. While the evidence-base is promising, results must be treated with some caution given the high risk of bias identified in many studies. It is clear that PE has a vital role to play in developing FMS for children and that PE specialists or classroom teachers with extensive and ongoing professional development are required to deliver such programs.

Table 2.2 Study and FMS intervention characteristics and findings

Reference (author, year country)	Design and Setting	Sample	Program Length & Total minutes	Intervention groups & facilitator[1]	Intervention content/theory or pedagogical approach	FMS Measure and Outcomes	Posttest and Follow-up duration	Retention & results
Akbari et al (2009) Iran	Quasi-experimental, 1 primary school	N = 40 boys Age = 7-9 yr	8 wk Total = 1440 mins.	INT: Traditional games CON: usual daily activities **Facilitator**: INT: Not clear CON: Not clear	INT: 3× 60-min sessions per week according to a specific lesson plan, including 1. Warm-up, 2. Traditional games; culturally appropriate and relevant for Iran with multiple skills practices for both locomotor and object control, 3. Cool down CON: Games such as football, computer games and cycling **Approach**: INT: Direct instruction CON: Not detailed	TGMD-2 (locomotor: run, gallop, leap, jump, hop, slide; object-control: throw, catch, kick, strike, dribble, roll)	PT: 8 wk FU: none	RET: not clear PT: INT>CON for gross motor skills (p<0.001), locomotor skills (p<0.001) and object-control (p<0.001) **Adjustments/effects by sex[2]**: N/A (boys only).
Bakhtiari et al (2011) Iran	RCT, 1 primary school	N = 40 girls Mean age = 8.9±0.5 yr Grade = third	8 wk Total = 1080 mins.	INT: Selected exercises CON: control **Facilitator**: INT: Not clear CON: Not clear	INT: 3× 45-min sessions per week of selected exercises according to a specific lesson plan, including 1. Heating, 2. Selected exercises, 3. Cooling CON: not described **Approach**: INT: Direct instruction	TGMD-2 (locomotor: run, gallop, hop, leap jump, slide; object-control: throw, catch, kick, strike, dribble, roll)	PT: 8 wk FU: none	RET: 100% PT: INT>CON for locomotor skills (p=0.001), object-control skills (p=0.001) and overall motor development (p=0.001) **Adjustments/effects by sex[2]**: N/A (girls only).
Boyle-Holmes et al (2010) United States	Quasi-experimental, 16 primary schools	N = 1464 (49% girls) Age = 8-12 yr (mean	2 yr Total = 3060	INT: Michigan's Exemplary PE Curriculum (EPEC)	INT: EPEC is a developmental PE curriculum that focuses on teaching and cumulative and connected motor skill learning	Measure developed for study (locomotor: leap; object-	PT: 6-month, 12-month, 18-month	RET: 18-month PT – 1195/1464 (81.6%) PT: Overall average effects over time: INT>CON for

		age = 9.8 yr) Grade = fourth and fifth	mins. p/yr	CON: existing PE curricula **Facilitator**: INT: PE teachers CON: PE teachers	progressions that strongly incorporated assessment and feedback. Lessons focused predominantly on the following three standards: motor skill and movement, values of physical activity for health and enjoyment, and regular physical activity. 51 lessons per grade throughout the school yr, 2 x 30-min lessons per week. Dose was on average 44 lessons per yr (75%) CON: eclectic collection of materials. Lessons focused predominantly on three standards from the Michigan PE content standards: motor skill and movement, movement concepts, and responsible personal and social behavior. 48 lessons per yr; similar frequency and duration to INT. **Approach**: INT: Direct instruction with developmental focus CON: Direct instruction	control: forehand strike)	FU: none	forehand strike (p<0.05) INT>CON for leap (p<0.05) for the fifth-grade cohort **Adjustments/effects by sex**: Not reported.
Cliff et al (2011) Australia	RCT, After-school community	N = 165 (59% girls) Age = 5.5-9 yr	6-month Total = 900 mins.	INT 1: Physical activity skill development program (PA) INT 2: Dietary	INT 1: guided by CMT. 10-wk face to face program (weekly 90 min. group session and weekly "home challenge" activities) and a minimal-contact 3-month	TGMD-2 (locomotor: run, gallop, hop, leap, horizontal jump, slide; object-	PT: 6-month FU: 12-month	RET: PT – 109/165 (66.1%) FU – 89/165 (53.9%) PT: INT 1 and INT 3 > INT 2 for locomotor subscale (p<0.01), object-control

		Overweight or obese children (78% obese)		modification program (DIET) INT 3: Combined physical activity and dietary modification program (PA+DIET) **Facilitator**: INT 1 & 3: Researchers (PE qualified)	maintenance phase. INT 2: Parent-only program focused on improving food behaviors and diet quality. INT 3: Identical versions of PA and DIET interventions, with parents and children participating concurrently. **Approach**: INT 1 & 3: Based on competence motivation theory. Both direct instruction, movement exploration, guided discovery and independent practice.	control: strike, dribble, catch, kick, throw, roll)		subscale (p<0.01), and GMQ (p<0.001) (GMQ gains of 11%-13%) FU: There were no significant between group differences for locomotor subscale, object control subscale or GMQ. **Adjustments/effects by sex[2]:** No significant sex interaction effects in models.
Cliff et al (2007) Australia	Single group pre-test post-test design, After-school community	N = 13 (64% girls) Age = 8-12 yr (mean age = 10.4±1.2 yr) Overweight or obese children (BMI 24.81±3.1 kg/m^2)	10 wk Total = 1200 mins.	INT: SHARK **Facilitator**: INT: Researcher (PE qualified)	INT: 10-wk after school program to develop six locomotor (run, gallop, hop, leap, horizontal jump, slide) and six object-control (two-handed t-ball strike, stationary dribble, catch, kick, overhand throw, underhand roll) skills. Weekly 2-hr group session focused on 2/3 skills and included introduction, skill-development and skill application activities, debrief, and "home challenge" tasks. Each lesson used TARGET (Task, Authority, Recognition, Grouping, Evaluation, Time) structure.	TGMD-2 (locomotor: run, gallop, hop, leap, horizontal jump, slide; object-control: strike, dribble, catch, kick, throw, roll)	PT: 10 wk FU: 9-month	RET: PT and FU – 11/13 (84.6%) PT: INT significant increase in GMQ (p<0.001) FU: INT GMQ remained significantly higher (p=0.019) **Adjustments/effects by sex[2]**: Not reported.

					Approach: INT: Mastery motivational climate and based on competence motivation theory.			
de Araujo et al. (2012) Brazil	Quasi-experimental post-test only, 2 primary schools	N = 41 (39% girls) Age = 9-11 yr Grade= fourth	Not reported	INT: Extreme sports classes CON: Existing physical education **Facilitator**: INT: PE teacher CON: PE teacher	INT: 3 x extreme sports weekly classes (including skateboarding, roller-skating, climbing, parkour activities) and 2 x weekly PE classes. CON: 2 x weekly PE classes. **Approach**: INT: Not clear CON: Not clear	TGMD-2 (locomotor and object control subtests)	PT: not reported	RET: not clear PT: INT>CON for locomotor skills ($p<0.05$) No difference between groups for object control skills. **Adjustments/effects by sex** [2]: Not reported.
Ericsson (2008a) Sweden Ericsson (2008b)	Quasi-experimental, 1 primary school	N = 251 Age = 6 yr	9 yr Total = 11,700 mins. each yr	INT: MUGI motor training program CON: Existing physical education **Facilitator**: INT: PE teacher CON: PE teacher	INT: 5 x lessons of physical education and physical activities per week (PE 3 lessons and local sport club took for 2 lessons), and if needed 1 x extra lesson (45-min) of motor training per week. MUGI includes motor skill observations, information to teachers and parents and identification and additional support for children with motor skill problems. Principles of MIGI include: (1) Success instead of failure (2) No training of skills the child cannot perform (3) Automisation of skills in	MUGI observation checklist (eye-hand coordination: throw and catch, bounce ball, obstacle course; balance ability and bilateral coordination: skip, hop on one leg, balance on one leg, involuntary movements, “ski hop”, imitate movements)	PT: school yr 2 and 3	RET: not clear PT: school yr 2: INT>CON for motor skills ($p<0.05$) (Cramér’s index = 0.24) PT: school yr 3: INT>CON for motor skills (Cramér’s index = 0.37) and largest in the variable balance/bilateral coordination Differences between boys and girls motor skills in CON increased (46% boys 83% girls had good motor skills in yr 3) No differences between boys and girls motor

Ericson (2011)	Quasi-experimental prospective controlled longitudinal study, 2 schools	N = 263 (51% girls)			earlier development CON: 2 x lessons of school's ordinary physical education per week (90 mins.). **Approach**: INT: Hypothetic-deductive CON: Not clear		PT: school yr 9	abilities in INT (90% boys 94% girls had good motor skills in yr 3) RET: school yr 9 – 245/263 (93.2%) PT: school yr 9: INT>CON for motor skills (Cramér's index = 0.62) CON 42% boys 33% girls had good motor skills INT 93% boys 92% girls had good motor skills **Adjustments/effects by sex**: No adjustments or interactions reported.
Foweather et al (2008) England	Cluster randomized controlled trial, After-school (2 primary schools in areas of high deprivation)	N = 34 (62% girls) Age = 8-9 yr Grade = fourth	9 wk Total = 1080 mins.	INT: Multi-skills club CON: Normal routines **Facilitator**: INT: Experienced coaches with sports coaching qualifications CON: N/A	INT: Semi-weekly after-school club with 2 x 1-hr sessions each week (total 18 hr) focusing on FMS (vertical jump, leap, sprint run, kick, catch, throw, static balance) development. Program consisted of a variety of games, drills and self-learning activities. CON: normal routines and not engaged in additional sport programs **Approach**: INT: Direct & self-learning CON: N/A	Modified checklist developed using 'Get skilled: get active' (vertical jump, leap, sprint run, kick, catch, throw, static balance)	PT: 9 wk FU: none	RET: 34/47 (72.3%). Children attended 80% of sessions. PT: INT>CON for static balance (p=0.005) **Adjustments/effects by sex:** Preliminary analysis revealed intervention effects "did not significantly differ by sex" (p value not reported).

Ignico (1991) United States	Quasi-experimental, 1 primary school	N = 30 Grade = kindergarten	10 wk Total = 480 mins.	INT: competency-based assessment and instructional program CON: Regularly scheduled free play **Facilitator**: INT: 3 upper level university preservice teachers (PE majors) CON: N/A	INT: Students rotated between 3 stations (9-min each). Received instruction, demonstration and feedback on specific performance criteria of 12 motor skills. Student/teacher ratio was 6: 1. Total instruction time of approximately 28-min each day. Preservice teachers received training in motor skill assessment for 3 weeks. CON: participate in free play activities (approximately 20-25-min each day) **Approach**: INT: Direct instruction CON: Free play	TGMD (locomotor: run, hop, jump, slide, gallop, skip, leap; object-control: dribble, kick, throw, catch, strike)	PT: 10 wk FU: none	RET: 100% PT: INT>CON for GMQ (p=0.0001) **Adjustments/effects by sex**[2]: Intervention effects did not differ by sex (p = 0.27).
Kalaja et al. (2012) Finland	Quasi-experimental, 3 secondary schools	N = 446 (52% girls) Age = ~ 13 yr Grade = seventh	33 weeks Total = 825 mins.	INT: Professional development for teachers and FMS training sessions for students CON: regular school PE program **Facilitator:** INT: PE teachers (2 to 10 yr experience)	INT: 33-week intervention that included FMS training sessions focusing on developing one dimension of FMS (i.e., locomotion, manipulation or balance). FMS sessions were 25 mins in duration and were scheduled at the beginning of PE class. Sessions included differentiation and promoted a mastery climate. After the FMS session, PE teachers followed regular school PE program (involving practicing sport skills, such as orienteering,	Flamingo standing test, rolling test, leaping test, shuttle run test, rope jumping test, accuracy throwing test, figure-8 dribbling test.	PT: 10 months FU: 17 months	RET: not clear PT: INT>CON for flamingo standing test (p=0.001), INT>CON for rolling test (p=0.000), INT>CON for balance skill sum score (p=0.000), INT>CON for movement skills sum score (p=0.000) FU: INT>CON for flamingo standing test (p=0.046), INT>CON for balance skill sum score (p=0.014)

				CON: PE teachers (5 to 15 yr experience)	volleyball and skiing). CON: One 90 minute weekly PE lesson for 33 weeks. **Approach:** INT: Mastery climate CON: Direct instruction			**Adjustments/effects by sex:** Not reported.
Karabourniotis et al. (2002) Greece	Randomized controlled trial, 1 primary school	N = 45 (47% girls) Mean age = 79 months Grade = first	12 wk Total = 960 mins.	INT: Skill-orientated program with focus on self-testing activities CON: regular PE school program **Facilitator**: INT: PE specialists CON: PE specialists	INT: 12-wk experimental movement skill curriculum with an increasing allotment of time spent on self-testing activities (including FMS, sports skills, fitness activities, activities with small and large equipment) which allow students opportunities to perform individually. 2 x 40-min sessions per week. CON: PE curriculum 12-wk program originally suggested by the Greek Ministry of National Education and Religious Affairs (space and time perception activities; visual-motor coordination activities; static and dynamic balance; sideways movement). **Approach**: INT: Movement exploration (Mastery/self-testing) CON: Direct instruction	TGMD (locomotor: run, gallop, hop, horizontal jump, leap, skip, slide; object-control: throw, catch, dribble, kick, strike)	PT: 12 wk FU: none	RET: not clear PT: INT>CON for total motor score (p<0.001), locomotor subscale (p<0.001) and object-control subscale (p<0.001). **Adjustments/effects by sex[2]**: Not reported.

Martin et al. (2009) United States	Quasi-experimental, 2 primary schools (Schools economically disadvantaged)	N = 64 (53% girls) INT mean age = 5.7 yr CON mean age = 5.4 yr Grade = kindergarten	6 wk Total = 900 mins.	INT: mastery motivational climate CON: low autonomy climate **Facilitator**: INT: Researcher/ PE specialist (6 yrs experience) CON: PE specialist (8 yrs experience)	INT: mastery motivational climate where students move freely throughout FMS stations and have choice in which stations to visit, time, level of task difficulty, and grouping. Teacher provides private individual feedback about effort or progress. 30 x 30-min lessons CON: low autonomy climate that utilized direct teaching methods, skill drills, sport skills and large group activities. 30 x 30-min lessons. Both INT and CON lessons consisted of 3 parts: (a) 3-5mins. Introduction (b) 22-25 mins. of skill instruction and practice & (c) 2-3 mins. of closure. **Approach**: INT: Mastery motivational climate CON: Direct instruction	TGMD-2 (locomotor: run, gallop, hop, leap, jump, slide; object-control: strike, dribble, catch, kick, throw, roll)	PT: 6 wk FU: none	RET: 53/64 (82.8%) for locomotor subscale, 54/64 (84.4%) for object-control subscale PT: INT>CON for locomotor subscale (p=0.001) and object-control subscale (p=0.001) **Adjustments/effects by sex**[2]: Not reported.
Matvienko et al (2010) United States	Quasi-experimental, After-school, 4 primary schools	N = 70 (50% girls) Grade = kindergarten and first	4 wk Total = 2100 mins.	INT: NutriActive (morning walk & after-school program) CON: control **Facilitator**: INT: PE	INT: Daily 15-min morning walk and 90-min after-school physical activity lesson with an emphasis on motor skill development (20 mins.), nutrition/health lesson (30 mins.), snack, and non-structured active play.	Fitnessgram throwing distance test. Additional measures developed for study: rope jumping (number of basic jumps	PT: 4 wk FU: 4-month	RET: PT – 100% FU - 59/70 (84.3%) PT: INT>CON for jumps over rope, throwing and kicking (p<0.05) FU: INT>CON for jumps over rope (p<0.001) and throwing (p<0.001)

				specialist CON: N/A	CON: did not receive any intervention **Approach**: INT: Direct instruction CON: N/A	over the jump rope in 30-seconds); kicking (kicking a ball into the goal from a 10-m line)		**Adjustments/effects by sex**: Not reported.
McKenzie et al (1998), United States	Cluster randomized controlled trial, 7 primary schools	N = 709 (50% girls) Mean age of girls = 9.4yr Mean age of boys = 9.6yr Grade = fourth and fifth	6 months Total = 2160 mins.	INT 1: PE Specialists (PES) INT 2: Trained Teachers (TT) CON: usual PE **Facilitator**: INT 1: PE specialists + additional SPARK training (1 had 11yrs experience, the others newly credentialed) INT 2: Trained classroom teachers CON: Classroom teachers	INT 1: PE Specialists implemented the SPARK PE curriculum (focused on fitness (15 mins.) and motor skills (15 mins.) and included all lesson plans. 3 x 30-min lessons per week. Received bimonthly meetings offsite including review and feedback. INT 2: Classroom teachers implemented the SPARK PE curriculum. 3 x 30-min lesson per week. Classroom teachers received training (Classroom Teacher Professional Development Program. Yr 1 = 32-hr over 11 sessions, Yr 2 = 9-hr over 3 sessions). Also received onsite support by PE specialist (biweekly to bimonthly) including observations, modeling, feedback etc.) CON: Continued with usual PE programs	Overhand throw (overhand throw a ball to hit a target); catch (catch a ball that was tossed underhand); kick (kick a stationary ball into a target)	PT: 6-month FU: none	RET: 100% (95 removed from baseline analysis, 12 unavailable) PT: INT 2>CON for catching (p=0.005) and throwing (p=0.008) For total skill percent gains INT 1 increased by 21%, INT 2 by 19% and CON by13% **Adjustments/effects by sex:** Significant main effect of sex for all skill changes (all p <0.001). Both improved but boys made significantly greater motor skill gains than girls. Intervention effects did not differ by sex.

					Approach: INT: Direct instruction CON: Not detailed.			
Mitchell et al. (2013) New Zealand	Single group pre-test post-test design, 11 primary schools	N = 701 Age = 5-12 yr Grade = K-8	6 wk	INT: Tailored FMS PE lessons **Facilitator:** INT: Classroom teachers	INT: Project Energize team members provided and discussed targeted physical education plans with classroom teachers. Materials were sourced from the Kiwidex and SPARC, Developing Fundamental Movement Skills manuals. Skills and activities were included in their physical education and fitness classes. After baseline assessments, children set their own goals for skills they wanted to improve. **Approach:** INT: Not detailed.	TGMD-2 (kick, throw, strike, skip, jump, leap, gallop, bounce, catch, hop, slide, run)	PT: 6 wk FU: none	RET: not clear PT: INT significant increase for all skills ($p<0.003$) **Adjustments/effects by sex**[2]: Not reported.
Ross et al (1989) United States	Single group pre-test post-test design, 1 primary school	N = 120 (45% girls) Age = 5-14 yr Grade = K-8	36 wk Total = K-3: 2160 mins. Grades 4-8: 3240 mins.	INT: Dance / movement education (D/ME) **Facilitator**: INT: PE specialist (10yrs experience) + 2 dance teachers	INT: D/ME in conjunction with the school's regular PE program instructed by the school's regular physical educator in cooperation with two dance educators. D/ME emphasized Laban's principles of force, space, time and flow. Video feedback was used to augment instruction, 2 x 30-min lessons per week for K-3. 2 x 45-min lessons per week for grades 4-8.	Ohio State University Scale of Intra Gross Motor Assessment (SIGMA) (running, stair climbing, jumping, hopping, skipping) (only assessed K-3	PT: 9-month FU: none	RET: not clear PT: K-3 boys made gains in the number of mature gross motor patters for running, jumping and hopping (no p-value reported) K-3 girls made gains in the number of mature gross motor patters for running, jumping, hopping and skipping (no

					Approach: INT: Dance/movement education (teaching specific movement education concepts; choreographing & rehearsing) + regular PE	n=63) The Short Form of the Bruininks-Oseretsky Test of Motor Proficiency (dynamic balance, static balance) (Assessed K-8 n=120)		p-value reported) K-5 boys increased dynamic balance ($p \leq 0.05$) K-2 girls increased dynamic balance ($p \leq 0.05$) **Adjustments/effects by sex:** Boys and girls analysed and reported separately.
Salmon et al (2008), Australia	Cluster randomized controlled trial, 3 primary schools (low SES areas)	N = 306 (51% girls) Mean age = 10 yr 8-month Grade = fifth	9-months Total = 855 mins. (FMS)	INT 1: behavioral modification (BM) condition INT 2: FMS condition INT 3: combined BM/FMS condition CON: control **Facilitator**: INT: PE specialist CON: Not detailed	Interventions guided by SCT and BCT and delivered in addition to usual PE and sports classes. INT 1: lessons (19 x 40-50 min) were delivered in the classroom and incorporated self-monitoring, health benefits of PA, awareness of home and community PA and sedentary behavior environments, decision-making, identifying alternate activities, intelligent TV viewing and reducing viewing time, advocacy of reduced screen time, use of pedometers, group games, contracts, and parent newsletter. INT 2: lessons (19 x 40-50 min) focused on mastery of six FMS (run, dodge, vertical jump, throw, strike, kick) with an emphasis on enjoyment and fun	Department of Education Victoria Fundamental Motor Skills: A Manual for Classroom Teachers (locomotor: dodge, sprint run, vertical jump; object-control: overhand throw, two-handed strike, kick)	PT:9-month FU: 12-month	RET: not clear PT and FU: no significant intervention effects on FMS z-scores. **Adjustments/effects by sex:** Some group x sex interactions noted for FMS INT 1 girls > CON girls for FMS z-scores ($p<0.05$) INT 2 girls > CON girls for FMS z-scores ($p<0.01$).

					through games and maximum involvement for all children. INT 3: received both BM and FMS (2 x 19 lessons) CON: usual curriculum **Approach**: INT: Games and skills drills. CON: Not detailed			
Sollerhed et al (2008), Sweden	Quasi-experimental, 2 primary schools	N = 132 (45% girls) Age = 6-9 yr	3 yr Total = 10,560mins. per yr.	INT: expanded PE lessons CON: stipulated curricular time **Facilitator**: INT: PE specialist and classroom teacher. CON: Classroom teacher	INT: increase of allocated time for PE. 4 x 40-min lessons and 1 x 1hr outdoor physical activities per week. Obese children had option of 1 x extra lesson per week. Quality of lessons and variety of activities were emphasized. One PE lesson boys and girls separate, the other co-ed. CON: followed the stipulated curricular time. 1 x 40-min lesson per week for children aged 6-9 yr and 2 x 40-min lessons per week for children aged 10-12 yr. **Approach**: INT: Not detailed CON: Not detailed	EUROFIT (plate tapping, shuttle run, balance). Tests constructed (rope skipping: number of correct skips with the rope in 30 s; ball bouncing: number of correct bounce catches in 30 s)	PT: 1 yr, 2 yr and 3 yr FU: none	RET: 3 yr PT – 126/132 (95.5%) PT: 3 yr: INT > CON for motor skill index (p=0.010) **Adjustments/effects by sex**: Results adjusted for sex.
Van Beurden et al (2003), Australia	Quasi-experimental,	N = 1045 (47% girls)	1 yr	INT: Move it Grove it CON: control	INT: Move It Groove It (MIGI): Whole school approach: school project teams; buddy program	'Get Skilled Get Active' (locomotor: static	PT: 1 yr FU: 6 yr	RET: not clear PT: INT>CON for all skills combined (p<0.0001)

	18 primary schools	Age = 7-10 yr Grade = third and fourth	**Facilitator**: INT: Trained classroom teachers and preservice teachers CON: Classroom teachers	(matching pre-service teacher [3rd Yr] with generalist teachers); professional development for teachers (one to introduce study, one mid-study to share progress, and two to improve teaching of FMS and dance); project website with lesson plans, ideas and activities; and funding for purchase of equipment ($AU375.00). Included all elements recommended by Ottawa Charter for Health Promotion. Included 5 day training + 4 professional development workshops for teachers.	balance, sprint run, vertical jump, hop, side gallop; object-control: kick, catch, overhand throw)	INT>CON for boys for sprint run (p<0.001), side gallop (p<0.001), kick (p<0.001), throw (p=0.034), jump (p=0.004) and catch (p<0.001) INT>CON for girls for side gallop (p=0.049), kick (p=0.023), throw (p=0.042), jump (p=0.002), hop (p=0.037), catch (p<0.001). Overall, 16.8% improvement for all skills combined (z = 9.64, P <0.0001).
Barnett et al (2009)		6-yr follow-up.		CON: not described **Approach**: INT: Direct instruction CON: Not detailed	'Get Skilled Get Active' (catch, kick, throw, vertical jump, side gallop)	RET: FU – 268/928 (28.9%) FU: INT>CON for catch (p=0.001) INT maintained advantage compared to CON for side gallop and vertical jump **Adjustments/effects by sex**: No interactions effects reported at post-test. Results adjusted for sex at 6 year follow up.

BCT, Behavioral choice theory; RCT, randomized controlled trial; INT, intervention; CMT, Competence motivation theory; CON, control; TGMD-2, Test for Gross Motor Development 2; PT, assessments conducted after baseline assessments and/or immediately following the completion of the intervention; FU, assessments conducted after the completion of the intervention and the initial post-test assessments ; RET, retention; PE, physical education; FMS, fundamental movement skills; GMQ, Gross Motor Quotient; SC, Social Cognitive Theory. [1] Facilitator - refers to the individual(s) who delivered the intervention. [2] TGMD standardized scores are all adjusted for age and sex.

Table 2.3 Risk of bias assessment in intervention studies examining changes in FMS in youth

Study	A) Randomization clearly described and adequately completed	B) Valid measure of FMS	C) Assessor blinding	D) Participants analyzed in allocated group & not excluded because of missing data or non-compliance	E) Covariates accounted for in analyses	F) Power calculation reported for FMS	G) Baseline results reported separately for each group	H) Dropout ≤20% for ≤6m follow-up and ≤30% >6 m follow-up	I) Summary results presented + estimated effect sizes + precision estimates
Akbari *et al.* 2009	N/A	✓	×	?	×	×	×	?	×
Bakhtiari *et al.* 2011	×	✓	×	✓	×	×	×	✓	×
Barnett *et al.* 2009	N/A	×	×	×	×	×	×	×	✓
Boyle–Holmes *et al*. 2009	N/A	×	✓	×	✓	×	×	✓	×
Cliff *et al.* 2007	N/A	✓	N/A	✓	N/A	×	✓	✓	×
Cliff *et al.* 2011	✓	✓	✓	✓	✓	×	✓	×	✓
de Araujo et al. (2012)	N/A	✓	×	N/A	×	×	×	?	×
Ericsson *et al.* 2008a	N/A	✓	×	?	×	×	×	?	×
Ericsson *et al.* 2008b	N/A	✓	×	?	×	×	×	?	×
Ericsson *et al.* 2011	N/A	✓	×	?	×	×	×	✓	×

Foweather *et al*. 2008	×	×	×	×	×	×	×	×	✓
Ignico *et al.* 1991	N/A	✓	×	✓	×	×	×	✓	×
Kalaja et al. (2012)	N/A	✓	×	✓	×	×	×	?	×
Karabourniotis *et al*. 2002	×	✓	×	×	×	×	×	×	×
Martin *et al*. 2009	N/A	✓	×	×	×	×	✓	✓	×
Matvienko *et al*. 2010	N/A	✓	×	×	×	×	×	✓	×
McKenzie *et al*. 1998	?	✓	×	×	×	×	✓	✓	×
Mitchell *et al.* 2013	N/A	✓	N/A	?	N/A	×	×	?	×
Ross *et al.* 1989	N/A	×	N/A	×	N/A	×	×	?	×
Salmon *et al*. 2008	?	✓	✓	✓	✓	×	×	?	×
Sollerhed *et al*. 2008	N/A	✓	×	×	×	×	×	✓	×
Van Beurden *et al*. 2003	N/A	×	×	?	✓	×	×	?	×

✓, explicitly described and present; × absent; ?, unclear or inadequately described; N/A, not applicable because of study design; FMS, fundamental movement skill(s)

CHAPTER 3. RATIONALE AND STUDY PROTOCOL FOR THE SUPPORTING CHILDREN'S OUTCOMES USING REWARDS, EXERCISE AND SKILLS (SCORES) CLUSTER RANDOMISED CONTROLLED TRIAL: A PHYSICAL ACTIVITY AND FUNDAMENTAL MOVEMENT SKILLS INTERVENTION FOR PRIMARY SCHOOLS IN LOW-INCOME COMMUNITIES

Preface:

This chapter presents the protocol paper for the Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES) cluster randomised controlled trial, which provides extensive detail on the study design, intervention components, assessment procedures and statistical analysis plan.

The content in this chapter is the final version of the article which is published in the journal *BMC Public Health*.

Citation:

Lubans, D. R., Morgan, P. J., **Weaver, K. (*now Cohen*),** Callister, R., Dewar, D. L., Costigan, S. A., Finn, T.L., Smith, J., Upton, L., & Plotnikoff, R.C. (2012). Rationale and study protocol for the SCORES group randomized controlled trial: A physical activity and fundamental movement skills intervention for primary schools in low-income communities. *BMC Public Health*, 12(1): 427-438.

Abstract

Background: At least one third of Australian children are insufficiently active to accrue health benefits and physical activity (PA) levels are consistently lower among youth of low socio-economic position. PA levels decline dramatically during adolescence and evidence suggests that competency in a range of fundamental movement skills (FMS) may serve as a protective factor against this trend.

Methods / design: The Supporting Children's Outcomes Using Rewards Exercise and Skills (SCORES) intervention is a multi-component PA and FMS intervention for primary schools in low-income communities, which will be evaluated using a group randomized controlled trial. The socio-ecological model provided a framework for the 12-month intervention, which includes the following components: teacher professional learning, student leadership workshops (including leadership accreditation and rewards, e.g., stickers, water bottles), PA policy review, equipment packs, parental engagement via newsletters, FMS homework and a parent evening, and community partnerships with local sporting organizations. Outcomes will be assessed at baseline, 6- and 12-months. The primary outcomes are PA (accelerometers), FMS (Test of Gross Motor Development II) and cardiorespiratory fitness (multi-stage fitness test). Secondary outcomes include body mass index [using weight (kg)/height (m^2)], perceived competence, physical self-esteem, and resilience. Individual and environmental mediators of behavior change (e.g. social support and enjoyment) will also be assessed. The System for Observing Fitness Instruction Time will be used to assess the impact of the intervention on PA within physical education lessons. Statistical analyses will follow intention-to-treat principles and hypothesized mediators of PA behavior change will be explored.

Discussion: SCORES is an innovative primary school-based PA and FMS intervention designed to support students attending schools in low-income communities to be more skilled and active. The findings from the study may be used to guide teacher pre-service education, professional learning and school policy in primary schools.

3.1. Background

Participation in physical activity is essential for optimizing children's physical, social, cognitive and psychological development [210, 211]. Activity of vigorous intensity may have additional benefits for young people, as physical fitness is a better predictor of metabolic health than total physical activity [212-214]. Unfortunately lack of physical activity among children and adolescents is a global concern [215] and current estimates suggest that only 50% of Australian primary school-aged children are meeting the current physical activity guidelines (i.e., 60 minutes/day of moderate-to-vigorous physical activity) [216]. In particular, promoting physical activity among youth from disadvantaged backgrounds is a public health priority because these individuals have reduced access to physical activity facilities and resources [24, 217] and are often less active than those of middle and high socio-economic position (SEP) [218-220].

The school setting is an ideal environment for the promotion of physical activity among youth as schools have the necessary equipment, personnel, facilities and curriculum to promote and provide opportunities for physical activity [221, 222]. Numerous school-based physical activity interventions have been evaluated [223, 224], including those specifically targeting youth from low-income backgrounds [225, 226]. Multi-component school-based interventions that involve parents and encourage physical activity within and beyond the school day, are more efficacious than curriculum only interventions [223, 224]. Although the evidence for effective school-based interventions is strong, studies rarely report their effect on movement skill competency. This is a notable omission because physical activity levels decline dramatically during adolescence [227, 228] and evidence suggests that failure to attain competency may contribute to this decline, whereas competency may serve as a protective factor against this trend [229, 230].

Proficiency in a range of fundamental movement skills (FMS) is considered to be the foundation for an active lifestyle [231] and the primary school years represent the "golden years" of motor skill development [231, 232]. FMS include locomotor (e.g., running and hopping), object control (e.g., catching and throwing) and stability (e.g., balancing and twisting) skills [231]. These skills are ideally developed in childhood

and subsequently refined into context- and sport-specific skills [232-234]. A recent systematic review of the health benefits associated with FMS competency found strong evidence for a positive association between FMS competency, physical activity and fitness in children and an inverse relationship between skill level and weight status [51]. Teaching movement skills improves both actual and perceived competence [235, 236], both of which are important for future physical activity [237, 238]. Indeed, lack of confidence in the physical domain is a major barrier to PA among many children and adolescents [239-241]. Alarmingly, many children finish primary school without achieving mastery in a range of FMS and those from disadvantaged backgrounds often demonstrate the lowest competency levels [219, 242].

The low physical activity and poor FMS competency observed among children living in low-income communities can be explained by socio-environmental factors (e.g., working parents, lack of physical activity opportunities and unsafe neighborhoods etc.) [243, 244] , but may also reflect a failure of current school-based programs and strategies [245]. Indeed, the recent Crawford report highlighted both the central role that schools play in the promotion of physical activity and the dire state of PE and school sport in Australian primary schools [245]. Formative research conducted by Morgan and colleagues indicated that the crowded school curriculum along with inadequate teacher training programs contributes to teachers' reluctance to teach PE and the poor quality of existing PE programs [246, 247]. Combined, these findings illustrate the importance of designing and evaluating school-based approaches to physical activity promotion among the most vulnerable individuals (i.e., those living in low-income communities). This paper provides the rationale and methods for the Supporting Children's Outcomes Using Rewards Exercise and Skills (SCORES) intervention. SCORES is a multi-component school-based intervention that combines a range of evidence-based behavior change strategies to promote physical activity and FMS competency among primary school aged children from low-income communities.

3.2. Methods / design

3.2.1. Study design

The SCORES intervention will be evaluated using a group randomized controlled trial (Figure 3.1). The 12-month multi-component physical activity and FMS intervention will target children in years 3 and 4 (ages 7 to 10 years) in eight primary schools. Assessments were conducted at baseline [February-March (Term 1) 2012], and will be repeated mid-program [August-September (Term 3) 2012] and at 12-months post baseline [February-March (Term 1) 2013]. The design, conduct and reporting of this group RCT will adhere to the Consolidated Standards of Reporting Trials (CONSORT) guidelines for group trials [248]. 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.

3.2.2. Setting and participants

The Socio-Economic Indexes for Areas (SEIFA) index of relative socioeconomic disadvantage was 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 well-being, 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. Eighteen government primary schools located in the Newcastle area, with a SEIFA index of ≤ 5 (lowest 50%) were invited to participate in the study and eight schools consented to participate in the study (50% consent rate). All students in grades 3 and 4 (Stage 2) 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).

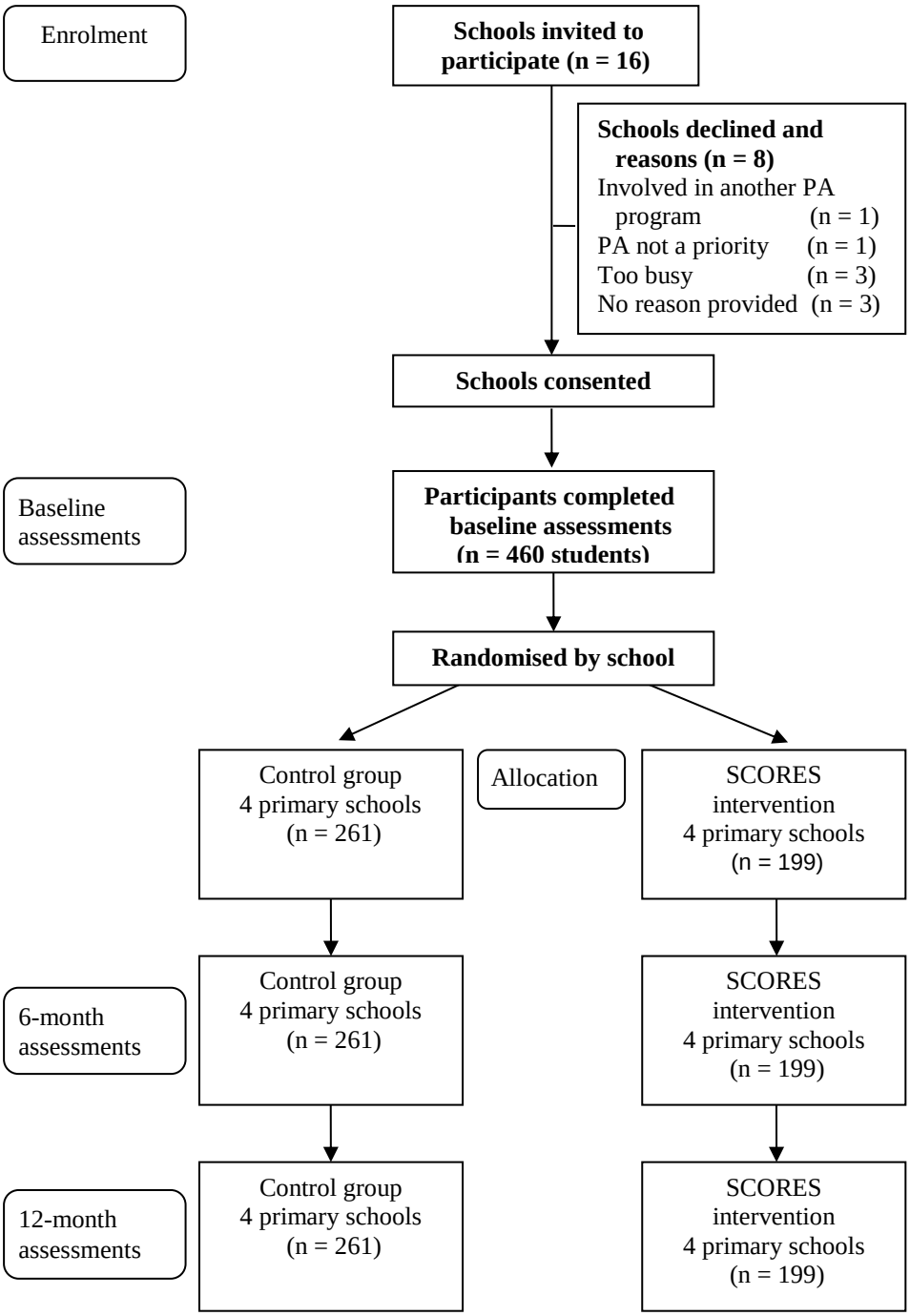

Figure 3.1 Study design and flow

3.2.3. Sample size calculation

Power calculations were conducted to determine the sample size required to detect changes in the three primary outcomes [i.e., physical activity, cardiorespiratory

fitness (CRF) and FMS] at the 12-month 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) [249], 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 [249]. Based on data from the Action Schools BC! (SD = 13) [250] and the KISS (ICC = 0.03) [249] 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., CFR outcome). In the absence of existing ICC values for FMS outcomes, an ICC estimate of 0.05 and a SD of 15 units [251] indicated that the study would be adequately powered to detect a between group difference of 5 units on the TGMD-2 gross motor quotient.

3.2.4. Blinding and randomization

Baseline assessments were conducted prior to randomization by trained research assistants. The research team will be organized into intervention and assessment teams. Only members of the assessment team will be involved in the collection of data to ensure blinding to group allocation. The intervention will be evaluated using a group RCT-design and schools were randomly allocated to the control or intervention groups for the duration of the study. Schools were match-paired based on their size and SEP (based on post-code of school) then randomly allocated to the intervention or control group using a computer-based random number producing algorithm by a researcher not involved in the current study. This method ensured that schools had an equal chance of allocation to each group.

3.2.5. Intervention

SCORES is a 12-month multi-component physical activity and FMS intervention for primary schools in low-income communities (Figure 3.2). The socio-ecological model [252] provided a framework for the intervention components. Within this framework, behavior change strategies were guided by self-determination theory (SDT) [253, 254] and competence motivation theory (CMT) [255, 256]. SDT

proposes that social-contextual factors (e.g., motivational strategies used by teachers and parents) can influence individuals' motivation and subsequent behavior by satisfying three basic psychological needs: 1) *Autonomy*, the need to experience one's behavior as self-endorsed or volitional; 2) *Competence*, the need to effectively interact with one's environment and achieve positive outcomes; and 3) *Relatedness*, the need to feel supported and connected with others [253, 254]. SDT has been used extensively with adolescents in PE-based research [257-260] and evidence suggests that students who feel self-determined are more engaged and more active in PE lessons [258, 259]. In the context of physical activity promotion, CMT provides a theoretical link between FMS competence and physical activity [255]. While CMT includes competence and a construct similar to SDT's relatedness (social support), it differs in its focus on enjoyment and includes global self-esteem as a predictor of behavior. Our integrated model proposes that children who have high levels of perceived and actual athletic competence, receive social support from significant others and feel a sense of control over their physical activity experiences will enjoy physical activity and seek opportunities to be active in the future.

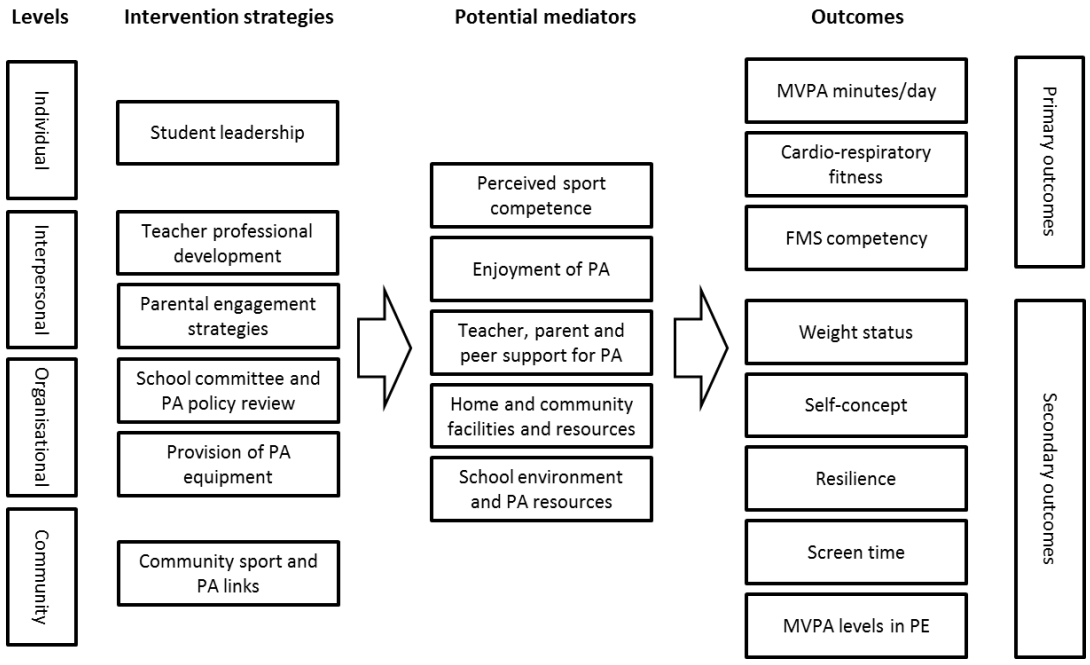

Figure 3.2 SCORES intervention components, potential mediators and outcomes

The SCORES intervention will be implemented in three phases. Phase 1 will focus on teacher professional learning, student workshops, provision of equipment and the establishment of a school committee. In Phase 2, the research team will work with the school committees to advocate for relevant policy change to promote physical activity and FMS. In addition, the research team will employ a range of strategies to engage parents and encourage them to support their children's physical activity. Phase 3 will address strategies to improve school-community links (e.g., inviting local sporting organizations to assist with school sport programs). The focus of this phase will be program consolidation and the research team will work with schools to establish sustainability. The intervention components are detailed in Table 3.2 and a description of how the socio-ecological framed intervention will facilitate behavior change at the individual, interpersonal, organizational and community levels is provided below:

Individual: While the intervention will involve a number of indirect strategies to support and improve children's physical activity behaviors (i.e., through teachers, parents and the community), students will be directly involved in the SCORES leadership workshops which will be delivered by the research team. The workshops will focus on developing leadership and organizational skills necessary for running lunch and recess physical activity sessions and assisting classroom teachers to deliver high quality PE lessons. These sessions will also provide students with an enjoyable physical activity experience and enable them to achieve SCORES leadership accreditation.

Interpersonal: The SCORES intervention will target teachers, parents and the students themselves as facilitators of behavior change. The teacher professional learning workshops will provide opportunities for non-specialist PE (i.e., classroom teachers) to improve their teaching skills and knowledge in regards to physical activity promotion and FMS development. The workshops were guided by SDT and CMT and will be used to reinforce the SAAFE (Supportive, Active, Autonomous, Fair and Enjoyable) teaching principles, which were developed for the study and are described in Table 3.1.

Parents will be engaged using the following strategies: a) newsletters describing intervention progress and encouraging physical activity and FMS practice, b) weekly FMS homework (using FMS activity cards to be completed by children at home under parental supervision), and c) a parent information evening focusing on parental strategies to promote physical activity and FMS development outside of school setting. Finally, students who have gained SCORES accreditation will be responsible for organizing recess and lunch-time physical activities for other students in the study schools.

Organizational: The research team will work with the schools to implement evidence-based policy and practice that is supportive of all students' physical activity. The specific physical activity policies are provided in Table 3.2. A school committee will be established to guide a review of existing school policy and the implementation of new policy. The research team conducted an audit of each school's equipment and resources. Intervention schools will be provided with physical activity equipment (e.g., bats, balls etc.) to support physical activity promotion, based on their individual requirements.

Community: The research team will conduct an audit of sport and physical activity organizations within each school's local community. Community organizations will then be invited to visit schools during PE and school sport. The aim of this intervention component is to create partnerships between schools and community organizations. It will also serve to increase students' awareness of, and participation in, extra-curricular sport and physical activity in their local community.

Control group: To prevent potential compensatory rivalry and resentful demoralization [261], the control schools will be provided with a condensed version of the program following the 12-month assessments. The condensed version of the program will include the professional learning workshops for teachers and students, strategies to engage parents and a review of school physical activity policy will be conducted. A physical activity equipment pack valued at approximately $1000 AUD (including pedometers, bats, balls, cones, goals etc.) will also be provided based on individual school requirements.

Table 3.1 SAAFE teaching principles and strategies

Principles	Strategies
Supportive – Lessons should be conducted in a supportive environment by both teachers and students.	1. Publicly recognize all students' effort, learning, achievements, and improvement. 2. Provide feedback on student effort, process and progress (not results). 3. Identify and manage inappropriate student behavior (e.g., teasing, over-competitiveness). 4. Promote positive social interactions between students.
Active - Lessons should involve a high level of movement and active learning time (ALT).	1. Use small-side games, circuits and tabloids to maximize participation. 2. Ensure equipment is plentiful and developmentally appropriate. 3. Monitor in-class physical activity using pedometers (i.e., approx. 75-85 steps/min of PE time is equal to 50% ALT). 4. Use student leaders to set-up games and activities.
Autonomous – Lessons should involve elements of choice and opportunities for graded tasks.	1. Ensure that tasks incorporate multiple challenge levels, and give students the freedom to select level of difficulty. 2. Provide students with opportunities to create and modify rules and activities. 3. Provide students with opportunities for leadership roles. 4. Encourage students to assess their own skill performances (e.g., detect and correct their own errors).
Fair – Lessons should provide all students with an opportunity to experience success.	1. Ensure tasks are not dominated by the most competent students. 2. Modify the tasks to increase the opportunity for success (i.e., make the goals bigger, reduce the number of defensive players, alter the equipment used, revise the task rules). 3. Ensure students are evenly matched in competitive activities. 4. Acknowledge and reward participation and good sportsmanship.
Enjoyable – Lessons should be enjoyable.	1. Include a wide variety of games and activities. 2. Provide engaging and age appropriate tasks. 3. Avoid boring and repetitive activity (e.g., running around the field for a warm-up). 4. Don't use exercise or activity as punishment.

3.2.6. Outcomes

Baseline assessments were conducted by trained research assistants at the study schools. Mid-intervention (6-months) and post-intervention (12-months) assessments will also be conducted at the study schools. For consistency and accuracy a protocol manual, which includes specific instructions for conducting all assessments, was developed and will be used by research assistants. Questionnaires will be completed before the physical assessments in exam-like conditions and physical assessments

will be conducted in a sensitive manner (e.g., weight measured in a discreet, private setting). Demographic information including age, gender, ethnicity, language spoken at home and mother/father's highest level of school was collected at baseline. A range of primary and secondary outcomes and hypothesized mechanisms of behavior change will be measured.

3.2.6.1. Primary outcomes

Physical activity: Physical activity will be assessed using triaxial Actigraph accelerometers (GT3X and GT3X+), which will be worn by participants during waking hours for seven consecutive days, except while bathing and swimming. Trained research assistants, following standardized accelerometer protocols [262], will fit the monitors and explain the monitoring procedures to students. Data will be collected and stored in 10-second intervals. The mean activity counts per minute (CPM) and daily step counts will be calculated, while thresholds for activity counts will be used to categorize physical activity into sedentary, light, moderate and vigorous intensity activity [263].

Cardio-respiratory fitness: CRF will be assessed using a 20m multistage fitness test [264]. Participants will be required to run back and forth between two lines over a 20m distance within a set time limit. Running speed will start at 8.5 km/hour and will increase by 0.5 km/hr each minute using the Multi-stage test cadence CD. Participants will be instructed to run in a straight line and to place one foot over the 20 m line before the next beep. The test is completed when a participant fails to reach the line for two consecutive shuttles. Scores will recorded as the level and shuttle reached, which will be converted to the number of 20m laps completed to provide a continuous variable for analysis.

Fundamental movement skill competency: FMS competency will be assessed using the Test of Gross Motor development (TGMD) 2 [251]. 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 will perform each skill twice and skills will be

video-taped for assessment. Inter-rater and intra-rater reliability will be established (> 80%) using pre-coded video-tapes before movement skills are assessed.

3.2.6.2. Secondary outcomes

Height and weight: Weight will be measured in light clothing without shoes using a portable digital scale (Model no. UC-321PC, A&D Company Ltd, Tokyo Japan) to the nearest 0.1kg. Height will be recorded to the nearest 0.1 cm using a portable stadiometer (Model no. PE087, Mentone Educational Centre, Australia). Body mass index (BMI) will be calculated using the standard equation (weight[kg]/height[m]^2) and BMI-z scores will be calculated using the 'LMS' method [265].

Self-concept: Global self-concept will be assessed using Harter's Self-Perception Profile (SPP) [266]. The SPP utilizes a four-choice structured alternative format to reduce socially desirable responses. Participants must first decide which of the two statements best describes them and then choose whether the statement is 'sort of true' or 'really true' for them. Each item is scored from 1 (*low-self-perception*) to 4 (*high self-perception*).

Resilience: Participants will complete the Child and Youth Resilience Measure (CYRM-28) [267]. Based on a validation study involving children from 11 countries, the CYRM-28 was found to have good content-related validity and provide a culturally sensitive measure of youth resilience [268]. The CYRM-28 has 28 items and includes three sub-scales: individual, relationships with primary care-givers, and contextual factors that facilitate a sense of belonging. Items are rated on a 5-point Likert scale with values ranging from 1 (*Not at all*) to 5 (*A lot*).

Screen time: Participants will complete six items related to weekday and weekend day recreational screen time from the Health Behavior in School-aged Children (HBSC) study [269]. The HBSC screen time questions compare favorably with other measures in sedentary behavior [270] and has acceptable reliability in children, with intraclass correlation coefficients ranging from 0.86 (95% CIs, 0.76-0.92) for watching television on school days to 0.38 (95% CIs, 0.10-0.60) for using the internet for non-school purposes and chatting on line [271].

3.2.6.3. Hypothesized mediators of behavior change

A poor understanding of the mechanisms of behavior change in physical activity interventions has been noted in the literature [272, 273]. Students, parents and teachers will complete a range of scales assessing individual and socio-environmental level mediators of physical activity behavior change.

Perceived sport competence: Perceived sport competence will be assessed using a subscale from Harter's SPP [266].

Enjoyment: Enjoyment of physical activity will be assessed using the Physical Activity Enjoyment Scale (PACES) [274]. The 16-item scale is scored on a 5-point Likert scales, with responses ranging from 1 (*Disagree a lot*) to 5 (*Agree a lot).*

Social support: Social support from family/household members [275], friends [275] and teachers [276] will be self-reported by participants using existing scales (each containing 5 items). All scales utilize 5-point Likert scales with responses ranging from 1 (*never*) to 5 (*always*). Parents will also report the level of social support they provide for their children using the Children's Leisure Activities Study Survey (CLASS) [277].

Environment: Parents will complete selected scales from the CLASS assessing children's access to physical activity facilities and equipment in their home and local community [277]. Parents will also report barriers and facilitators to their children's physical activity in the local community using the CLASS. Teachers at the study schools will report on their schools' physical environment and facilities and students' access to these within and beyond the school day using scales selected from the New South Wales Schools Physical Activity and Nutrition Survey (SPANS) [278].

3.2.7. Process evaluation

A range of process data will be collected to complement the outcome data. Process measures will include i) teacher and student attendance at workshops (i.e., percentage attendance), ii) student leadership accreditation (i.e., number of students who complete the workshop and satisfy the accreditation guidelines), iii) teacher

satisfaction with professional learning workshops (using workshop evaluation questionnaires at the end of Phase 1), iv) parental involvement will be determined using a process evaluation questionnaire (e.g. reading newsletters and completion of home-based FMS tasks) and attendance at the parent evening, v) teacher, student and parent satisfaction with all intervention components (using process evaluation questionnaires at the completion of the study), vi) compliance with physical activity policies will be determined through interviews with school Principal, vii) PE intervention fidelity will be determined (using SOFIT observations). PE lessons will be observed at baseline, 6- and 12-months using the System for Observing Fitness Instruction Time (SOFIT) tool [279]. Percentage of lesson time spent in MVPA and time dedicated to skill development will be assessed. All teachers of Stage 2 students (both intervention and control groups) will be observed at each time point.

3.2.8. Statistical methods

The study will be adequately powered to detect clinically important changes in the three primary outcomes at the 12-month assessments. Statistical analyses of the primary and secondary outcomes will be conducted using linear mixed models with PROC MIXED in SAS V 9.1 (SAS Institute Inc, Cary, NC) and alpha levels will be set at $p < 0.05$. The mixed models will be specified to adjust for the clustered nature of the data and will follow the intention to treat principle. Potential moderators of the intervention effects (e.g., ethnicity, socio-economic status and type of school) will be explored using linear mixed models. Differences between participants in the intervention and groups at baseline and differences between completers and those who drop out of the study will be examined using Chi square and independent samples t-tests in PASW Statistics 17 (SPSS Inc. Chicago, IL) software. Hypothesized mediators of physical activity behavior change will be examined using multilevel linear analysis and a product-of-coefficients test that is appropriate for cluster randomized controlled trials [280].

3.3. Discussion

In this paper we described the rationale and study protocol for the SCORES intervention. To the authors' knowledge, SCORES is the first physical activity and FMS intervention targeting Australian primary school children in low-income communities. Targeting children of low-SEP is important because they have reduced access to physical activity opportunities and are typically less active and skilled than youth of middle- and high-SEP [219, 220]. By Year 4, students should achieve mastery in a range of FMS, however, recent data suggests that the prevalence of advanced skills is low among Australian children and proficiency levels have declined since 2004 [219].

Although there is strong evidence that school-based physical activity interventions are effective in increasing the duration of physical activity and increasing CRF in children and adolescents, their impact on leisure time PA and FMS is less convincing [222-224]. Such programs are typically evaluated among youth transitioning from childhood to adolescence, a period of time that is characterized by an erosion of activity patterns [227, 281]. Nevertheless, recent well-designed studies [249, 250, 282], such as the KISS intervention [249] have demonstrated that multi-component school-based interventions can increase physical activity and CRF in children. However, these studies have involved daily PE lessons, which may not be feasible in many schools.

Alternatively, interventions that provide professional learning opportunities for teachers and promote physical activity within existing PE lessons and throughout the school day (i.e., lunch time and recess) may provide a valuable framework for sustainable practice. Unfortunately, many primary school teachers lack the confidence and skills to teach PE effectively [247, 283], which may explain their reluctance to teach this subject in favor of traditional academic subjects (e.g., mathematics and science). The lack of focus on teacher professional learning in school-based physical activity interventions is surprising considering the importance placed on professional learning in the general education literature [284] and that teachers have specifically stated that professional development in PE, and teaching

FMS in particular, is urgently needed and a high priority for improving physical activity-related outcomes in primary schools [283].

SCORES is an innovative multi-component school-based intervention targeting primary school children in low-income communities. The strengths of this study include the study design, the objective measures of physical activity, FMS and CRF and the comprehensive multi-component intervention. The findings from the study may be used to guide teacher pre-service education, professional learning and school policy in primary schools.

Table 3.2 Intervention components, behavior change techniques and targeted constructs in the SCORES intervention

Intervention component	Dose	Description	Behavior change strategies	Targeted constructs
1) Student leadership	1 x 2 hours	Students will be provided with an opportunity to achieve SCORES leadership accreditation. Students will attend the SCORES leadership workshop, which will be delivered at the study schools during PE/sport by the research team. This will provide students with formal acknowledgment (i.e. certificates) and rewards (i.e. water bottles, stickers) for their participation. SCORES leaders will be encouraged to set up (i.e. equipment monitor), run (i.e. deliver lunch and recess activities) and promote (i.e. speak on assembly) PA and FMS development in the school setting. Students who complete these tasks will have the opportunity to achieve a yellow award (complete 5 tasks), red award (complete 10 tasks), and blue award (complete 15 tasks), and receive the associated rewards (i.e. certificates, wrist bands, hats, sporting equipment).	▪ Provide instruction ▪ Model or demonstrate the behavior ▪ Provide contingent rewards ▪ Prompt identification as a role model ▪ Plan social support or social change ▪ Set graded tasks	▪ Actual competence ▪ Perceived competence ▪ Social support ▪ Enjoyment
2) Professional learning workshops for teachers		The research team will deliver professional development workshops for teachers. Workshops will focus on effective teaching methods for the development of FMS, strategies for teaching and assessing FMS, increasing MVPA and enjoyment in PE and school sport (based on the SAAFE teaching principles).	▪ Provide instruction ▪ Model or demonstrate the behavior ▪ Time management ▪ Provide feedback on performance	▪ Social support ▪ Actual competence ▪ Perceived competence
	1 x full day for Stage 2 teachers[1]	*i) Stage 2 teachers' workshop:* will be held at the university. This workshop will be provided for Stage 2 teachers only.		

		1 x half day for all teachers at intervention schools	*ii) Whole-school workshops:* will be delivered in the study schools during one of their scheduled professional learning days.		
3)	Parental engagement	4 x newsletters Weekly FMS homework 1 x Parent evening	*i) Newsletters* - Parents of study participants will be provided with newsletters to educate and encourage them to support their children's PA behaviors. Newsletters will also provide updates and feedback on the project. *ii) FMS Homework* – Students will be encouraged to complete practical homework tasks focused on FMS development with their parents/guardians. *iii) Parent evening* – Parents will be invited to attend an interactive information session on how to promote and increase PA and FMS in the home setting.	▪ Provide information on consequences ▪ Provide feedback on performance ▪ Plan social support or social change ▪ Provide general encouragement	▪ Social support ▪ Actual competence ▪ Perceived competence ▪ Enjoyment
4)	Policy and environment	On-going	*i) School committee and policy review and recommendations:* The research team will conduct a review of PA policy in the schools. The research team will work with Principals to revise policy to support the PA promotion. Policy recommendations include: a) Functioning school PA committee (i.e., school committee to meet once a school term). b) All students participate in at least 120 minutes of timetabled PA per week (i.e., ensure PE and school sport are timetabled).	▪ Provide opportunities for behavior ▪ Provide access to equipment to encourage behavior	▪ Physical environment ▪ Actual competence ▪ Perceived competence ▪ Social support ▪ Enjoyment

			c) 50% of PE and school sport time devoted to MVPA (i.e., lessons designed to maximize huff and puff activity). d) Annual reporting of students' FMS and fitness (e.g. report cards describing student levels). e) Promotion of active playgrounds (e.g. organised activities and access to equipment). f) Involve family members in school-based PA (e.g. parents as helpers in PE and school sport). *ii) Equipment and resources:* Each school will be provided with PA equipment (e.g. bats, balls etc) and resources (e.g. activity cards) to support the implementation of the intervention based on their individual school needs (approx. $1,000).		
5)	Community links	6 x visits	Community organizations (e.g. local football clubs) will be invited to the visit the study schools during PE/school sport. This will help to promote community sporting links.	▪ Provide instruction ▪ Model or demonstrate the behavior ▪ Provide information about opportunities in the local environment	▪ Actual competence ▪ Perceived competence ▪ Social support ▪ Enjoyment

FMS, Fundamental Movement Skills; PE, physical education; SCORES, Supporting Children's Outcomes using Rewards, Exercise and Skills.
[1]Stage 2 teachers are the classroom teachers of students in the intervention schools.

CHAPTER 4. MOVEMENT SKILLS AND PHYSICAL ACTIVITY AMONG CHILDREN LIVING IN LOW-INCOME COMMUNITIES: A CROSS-SECTIONAL STUDY

Preface:

This chapter presents the findings from a cross-sectional study examining the associations between FMS competency and objectively measured MVPA during school break-times and immediately after-school, which was conducted to investigate *Secondary Aim 2* of this thesis (i.e., to examine the association between FMS competency and objectively measured MVPA during time periods of the day that represent key physical activity opportunities (i.e., lunchtime, recess and after-school) among children attending primary schools located in low-income communities).

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Abstract

Background: Although previous studies have demonstrated that children with high levels of fundamental movement skill competency are more active throughout the day, little is known regarding children's fundamental movement skill competency and their physical activity during key time periods of the school day (i.e., lunchtime, recess and after-school). The purpose of this study was to examine the associations between fundamental movement skill competency and objectively measured moderate-to-vigorous physical activity (MVPA) throughout the school day among children attending primary schools in low-income communities.

Methods: Eight primary schools from low-income communities and 460 children (8.5 ± 0.6 years, 54% girls) were involved in the study. Children's fundamental movement skill competency (TGMD-2; 6 locomotor and 6 object-control skills), objectively measured physical activity (ActiGraph GT3X and GT3X+ accelerometers), height, weight and demographics were assessed. Multilevel linear mixed models were used to assess the cross-sectional associations between fundamental movement skills and MVPA.

Results: After adjusting for age, sex, BMI and socio-economic status, locomotor skill competency was positively associated with total (P=0.002, r=0.15) and after-school (p = 0.014, r = 0.13) MVPA. Object-control skill competency was positively associated with total ($p < 0.001$, r = 0.20), lunchtime (p = 0.03, r = 0.10), recess (p = 0.006, r = 0.11) and after-school (p = 0.022, r = 0.13) MVPA.

Conclusions: Object-control skill competency appears to be a better predictor of children's MVPA during school-based physical activity opportunities than locomotor skill competency. Improving fundamental movement skill competency, particularly object-control skills, may contribute to increased levels of children's MVPA throughout the day.

4.1. Background

Participation in physical activity is vital for enhancing children's physical, social, cognitive and psychological development [3]. Higher levels of physical activity in children are associated with improved fitness (both cardio-respiratory fitness and muscular strength) [285], enhanced bone health and reduced body fat [3]. Furthermore, children who regularly participate in physical activity have reduced symptoms of anxiety and depression, and improved self-esteem and confidence [3]. However, the number of children not participating in adequate amounts of physical activity to accrue the associated health benefits is a global concern [286]. Current estimates suggest that only 40% of Australian primary school-aged children are meeting the current physical activity guidelines of 60 minutes of moderate-to-vigorous physical activity (MVPA) every day [18]. Moreover, children from low socio-economic backgrounds are significantly less active than those of middle and high socio-economic backgrounds [13, 18].

Schools play a crucial role in providing opportunities for children to be physically active, as they have the necessary equipment, personnel, facilities and curriculum to promote activity [102, 107]. Beyond physical education and school sport, lunchtime and recess periods (break-time) offer ideal opportunities for children to be active on a daily basis [287]. If provided the choice to be active, the combined lunchtime and recess periods has the potential to contribute up to 40% towards children's daily physical activity recommendations [287]. Furthermore, the after-school period has been identified as a "critical window" for physical activity [288]. It is a unique period of time where children generally have the discretion to choose their own activities and if engaged in active pursuits, can contribute to approximately 25% of their daily physical activity [289]. It is therefore important to investigate potential factors that are associated with physical activity during key time periods for developing targeted physical activity interventions for children.

Fundamental movement skills (FMS) are considered the building blocks for movement and provide the foundation for specialized and sport-specific movement skills required for participation in a variety of physical activities. 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 [49]. Mastery of FMS is low among Australian primary school-aged children [58], and those from disadvantaged backgrounds often demonstrate the lowest levels of competency [13]. It is suggested that higher levels of FMS competency will provide greater opportunities for children to engage in a variety of physical activities, games and sports. In turn, children who are more skilled will choose higher levels of physical activity, while children who are less skilled will select lower levels of physical activity [290].

A recent systematic review of the health benefits associated with FMS competency found strong evidence for a positive association between FMS competency and physical activity in children [51], but also noted that the majority of studies had used self-report measures of physical activity [56, 291]. Such measures are limited by children's ability to accurately recall their behaviors and generally have low levels of validity and reliability in youth populations [14]. An additional concern is that few studies have adjusted their analyses for weight status, which may moderate the association between physical activity and motor skill proficiency [51, 60]. The associations between FMS competency and weight status has been well established, with FMS competency being inversely associated with weight status in children [51, 60]. Moreover, children who have a higher weight status participate in significantly lower amounts of MVPA [292].

Given the significant influence of physical activity on an individual's health, it is crucial to better understand the factors that influence physical activity levels among children, particularly those who are at most risk of being physically inactive. Current knowledge on the influence of FMS competency on physical activity levels in children from low-income communities is limited. Although previous studies have demonstrated that highly skilled children are significantly more active than children with lower levels of motor skill proficiency during PE lessons [293], little is known regarding the influence of FMS competency on children's physical activity during recess, lunch and immediately after-school. Therefore, the purpose of this study was to examine the associations between FMS competency and objectively measured MVPA during time periods of the day that represent key physical activity

opportunities for children (i.e., lunchtime, recess and after-school) among children attending primary schools in low-income communities.

4.2. Methods

4.2.1. Study design

Baseline data from the Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES) group randomised controlled trial was used for the current study. A detailed description of the SCORES study protocol has been published elsewhere [294]. In summary, SCORES was a 12-month multi-component physical activity and FMS intervention for children attending primary schools in low-income communities. Baseline assessments were conducted in February-April 2012 (summer-autumn). Ethics approval for the 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.

4.2.2. Setting and participants

Socio-Economic Indexes for Areas (SEIFA) index [295] of relative socioeconomic disadvantage was 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 [295]. Sixteen government primary schools located in the Newcastle region, NSW, Australia with a SEIFA index of ≤5 (lowest 50%) were invited to participate in the study and eight schools (mean SEIFA index of 3 ± 1.3) consented to participate (50% consent rate). All students in grades 3 and 4 (Stage 2) 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).

4.2.3. Measures

Trained research assistants conducted all assessments, which were completed at the study schools. 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.

4.2.3.1. Physical activity

Physical activity was assessed using triaxial ActiGraph GT3X and GT3X+ accelerometers (ActiGraph, LLC, Fort Walton Beach, FL). Output from the vertical axis was used. Vertical axis output from ActiGraph accelerometers appear to be comparable between different generations of ActiGraph accelerometers [296]. Accelerometers were worn by participants during waking hours for seven consecutive days, except while bathing and swimming. Trained research assistants, following standardized accelerometer protocols [297], fitted the monitors and explained the monitoring procedures to students. Data were collected and stored in 10-second epochs with a frequency of 30 Hz. Valid wear time for school-day physical activity (lunchtime, recess and after-school) was defined as a minimum of three weekdays with at least ten hours (600 minutes/day) of total wear time recorded. Valid wear time for total physical activity was defined as a minimum of three days including a weekend day with at least ten hours (600 minutes/day) of total wear time recorded; non-wear time was defined as strings of consecutive zeros equating to 20 minutes [33]. Thresholds for activity counts were used to categorize physical activity into moderate-to-vigorous intensity activity and minutes spent in this activity intensity [298]. The cut-points [298] used were published as 15-second thresholds and were divided by 15 and then multiplied by 10 to create cut-points for 10-second data [299]. Data was further categorized into lunchtime and recess time periods based on individual school timetables. Study schools were contacted at the start of the study and were asked to provide a day-by-day timetable for their recess and lunch breaks. Although we did not conduct direct observations during break times throughout the school day, schools are required by policy to adhere to the timetabled breaks. The lunchtime time period ranged from 45 to 50 minutes in duration and the recess time period was 20 minutes in duration. The after-school time period was

defined as the period of time from when school ended for each participant (3.00pm for all participants) to 6.00 pm.

4.2.3.2. Fundamental movement skills

FMS competency was assessed using the Test of Gross Motor Development (TGMD) 2 [63] which has established validity and reliability in children [63]. 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 [63]. 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 two assessors. Kappa values were also calculated to take into account agreement beyond chance. These were 0.97 for inter-rater reliability and ranged from 0.94 to 0.98 for intra-rater reliability.

4.2.3.3. Height and weight

Height was recorded to the nearest 0.1 cm using a portable stadiometer (Model no. PE087, Mentone Educational Centre, Australia). Weight was measured in light clothing without shoes using a portable digital scale (Model no. UC-321PC, A&D Company Ltd, Tokyo Japan) to the nearest 0.1 kg. Body mass index (BMI) was calculated using the standard equation (weight[kg]/height[m]2) and BMI-z scores were calculated using the 'LMS' method [300].

4.2.3.4. Participant demographics

Participating children completed a questionnaire to obtain demographic information including age, sex, language spoken at home, cultural background, Aboriginal or Torres Strait Islander decent, and suburb. The suburb of the child's residence was

used to determine their socio-economic status (SES) using the SEIFA index of relative socioeconomic disadvantage [295].

4.2.4. Statistical analyses

All analyses were performed using IBM SPSS Statistics for Windows, Version 20 (2011 SPSS Inc., IBM Corp., Armonk, NY). Prior to analyses, normality of the data were assessed and transformed where necessary. Total daily, lunchtime, recess and after-school MVPA minutes were log transformed. Sex differences in demographics, FMS and MVPA measures were tested using unpaired *t*-tests. To assess the cross-sectional associations between FMS (locomotor skills or object control skills) and MVPA multilevel linear mixed models were used, with MVPA (i.e., total daily, lunchtime, recess or after-school MVPA minutes) as the outcome variable, FMS (i.e., locomotor skills or object-control skills) as the predictor variable, sex, age, BMI-z score and SES as fixed factors (i.e. covariates), and school as a random factor. The mixed models were performed separately for each of the FMS measures (i.e., locomotor skills and object-control skills) and MVPA measures (i.e., total daily, lunchtime, recess and after-school MVPA minutes). The results of the multilevel linear mixed models were also expressed in the form of standardized regression coefficients. These coefficients were computed by initially calculating the mean and standard error for the variable. A new variable was subsequently created by subtracting the mean from the original value, and then dividing the difference by the standard error. The new standardized variables were used in the mixed models regression analyses. This process was performed for all outcome and predictor variables of interest. In all analyses, statistical significance was set at $p < 0.05$.

4.3. Results

4.3.1. Participant characteristics

The summary data and sex differences for participants' background, FMS and physical activity are presented in Table 4.1. Participating children (N = 460, 54% girls) had a mean age of 8.5 ± 0.6 years. Most of the participants (97.6%) reported English as their first language. 86.5% of participants reported Australian as their cultural background, 4.6% as European, 1.3% as African, 0.7% as Asian and 7% as

other. 13.8% of participants were of Aboriginal or Torres Strait Islander decent. 22.8% of the sample was overweight and 17% were obese. No sex differences were identified for age, BMI-z score or SES. Participating children's mean scores for locomotor and object control skills were 25.7 ± 5.8 and 24.2 ± 6.2 respectively. Girls were more competent on average in locomotor skills (p = 0.008), while boys were found to be more competent in object-control skills (p < 0.001). Participating children spent an average of 54.8 ± 19.7 minutes per day in MVPA. Compared with girls, boys spent more minutes in MVPA for all time periods. The data indicates that participating children accumulate approximately 50% of their daily MVPA during lunchtime, recess and after-school time periods combined.

4.3.2. Locomotor skills and MVPA

After adjustment for sex, age, BMI-z score and SES, locomotor skill competency was positively associated with total (p = 0.002) and after-school (p = 0.014) MVPA, but not with lunchtime (p = 0.075) or recess (p = 0.108) MVPA (Table 4.2).

4.3.3. Object-control skills and MVPA

After adjustment for sex, age, BMI-z score and SES, object-control skill competency was positively associated with total (p < 0.001), lunchtime (p = 0.030), recess (p = 0.006) and after-school (p = 0.022) MVPA (

Table 4.3).

4.4. Discussion

The aim of the current study was to examine the associations between FMS competency and objectively measured MVPA during time periods of the day that represent key physical activity opportunities for children. It was found that object-control skill competency, but not locomotor skill competency was significantly associated with children's MVPA during lunchtime and recess breaks at school. Children who were more competent at object-control skills and locomotor skills were engaged in more MVPA in the after-school period.

To the authors' knowledge, this is the first study to investigate the association between children's FMS competency and MVPA throughout key periods during the school day. Outside of curriculum time, lunchtime and recess periods provide important opportunities for children to be active within the school environment [287]. The current study found that object-control skill competency, but not locomotor skill competency, was significantly associated with MVPA during lunchtime and recess breaks. This finding may be indicative of the games and equipment provided to children during this time period. Games and activities such as soccer and basketball are popular break-time activities which are highly active and require high levels of object-control skill competency [301]. It is possible that the more skilled children dominate these games and the areas available for activity, thus increasing their activity levels and reinforcing the divide between the low skilled and high skilled children.

The school environment and existing policies may also influence children's activity levels during recess and lunch breaks [302]. Ridgers and colleagues [302] found that overall facility provision (i.e., sum of facilities available) and the provision of unfixed equipment, such as loose equipment, balls, skipping ropes, contribute to increased levels of physical activity among children during school break times. Providing children with access to a variety of facilities, spaces and equipment may encourage physical activity by increasing feelings of choice and supportive environments that foster physically active behaviors [302]. Interestingly, Ridgers and colleagues [302] found stronger effects for children who were less active at baseline. However, it is possible that such approaches will support the activity levels of more skilled children and fail to engage the least skilled individuals. Further research is needed to explore the impact of such policies on the activity of all students, regardless of their existing skill levels.

The significant contribution that physical education can make in the promotion of lifelong physical activity through the teaching of skills and positive behaviours has been well established [102, 303]. Fairclough and colleagues [293] found that the more highly skilled students engaged in more MVPA (approximately 5%) during physical education lessons than the less skilled students. Movement skill competency

may affect the degree to which skills are effectively performed, which could impact on the potential level of activity achieved in a physical education activity [293]. Thus, higher skilled children would be expected to be more active than less skilled children. Fairclough and colleagues [293] illustrated the need for teachers to use quality pedagogical strategies during physical education that provide all students with equal opportunities for successful movement skill acquisition and optimal physical activity engagement that can be then transferred outside of lessons. Moreover, it is noted that physical education should not be seen as a solution to overcome the increases in physical inactivity in children. Rather, it should be viewed as a regular educational environment (i.e., opportunity for children to learn movement skills) that complements other physical activity opportunities within the school environment. Physical education combined with other school-based opportunities, such as lunchtime and recess breaks, can make a valuable contribution to children's daily physical activity [102, 293, 304].

With increasing time during the after-school period spent indoors using electronic entertainment [305], it is important to identify the determinants of children's physical activity during this time. The after-school period is a "window of opportunity" for promoting physical activity and has the potential to make a substantial contribution to children's daily physical activity [306]. The study findings suggest that children who are more competent in object-control and locomotor skills participate in more MVPA during the after-school period. These results are consistent with existing evidence of cross-sectional studies in primary school aged children. Raudsepp and colleagues [307] reported the development level of FMS is associated with skill-specific after-school physical activity, with throwing and jumping skills related to higher intensity, skill-specific physical activity. Although these findings were similar to our study, Raudsepp and colleagues [307] only assessed two FMS (overhand throw and standing long jump) and used an observational tool to assess physical activity.

Although BMI was found to be a significant factor in children's MVPA, the findings in the current study demonstrate that locomotor skill competency and object-control skill competency was a stronger predictor of children's MVPA throughout the day

than BMI. This adds to existing evidence by Spessato and colleagues [308] who found that overall movement skill competency was a better predictor of physical activity during physical education lessons than BMI. This provides further evidence for the development of FMS competency as a key strategy in the promotion of children's MVPA.

Developing an understanding of the role of FMS competency in promoting physical activity is an important health priority. It is important to consider the bidirectional relationship between FMS and physical activity i.e., whether higher FMS competency increases a child's physical activity or whether greater participation in physical activity improves FMS competency. Due to the cross-sectional design of the current study, the direction of this relationship cannot be inferred. There is limited research investigating the potential causal relationships between FMS competency and physical activity behavior. However, Barnett and colleagues [309] found a reciprocal relationship between object-control competency and MVPA, and a one-way relationship from MVPA to locomotor skill competency. Although the explicit development of movement skills appears to be an important focus for increasing children's physical activity levels, it is also important to consider the impact of movement opportunities. It is suggested that if the relationship between skill competency and physical activity is viewed as a "positive feedback loop", skill development and increasing physical activity should be simultaneously targeted [309]. This has important implications for school and after-school programs, policy and practice. Providing quality teaching of FMS during physical education and sport [102], may be as equally important as ensuring the lunchtime and recess environment is conducive to physically active choices (i.e., providing access to sporting equipment during breaks, and utilizing sports equipment and games that target both locomotor and object-control skill use) in the promotion of children's physical activity [302].

Recent reviews of the effectiveness of physical activity interventions [104, 310] have reported modest findings in the promotion of physical activity. This may be in part due to an inadequate understanding of the unique primary factors that influence physical activity for a particular population i.e., low socio-economic position, in a

specific context i.e., lunchtime, recess or after-school. In light of these findings, future physical activity interventions are encouraged to focus on improving children's FMS, providing physical activity opportunities and environments for skill practice and application during school break-times and after-school.

4.4.1. Strengths and limitations

The current study has a number of strengths, including the use of a comprehensive qualitative assessment of movement characteristics of all major FMS, an objective measure of physical activity, adjustment of all analyses for confounders, and a relatively large sample size. However, there are some limitations that should be noted. Accelerometers underestimate certain types of physical activity as they cannot be worn in the water and are insensitive to non-ambulatory activity such as cycling. Accelerometer wear time criteria are typically generated from whole-day data, therefore it is uncertain if the same criteria can be applied to discrete segments of the day [311]. Due to the cross-sectional design of this study a cause-and-effect relationship between FMS and physical activity cannot be inferred.

4.5. Conclusions

Findings from the current study suggest that children who are more competent in FMS spend more time engaged in MVPA, in particular during time periods of the day that represent key physical activity opportunities for children. Children who are more competent in object-control skills are engaged in more MVPA during lunchtime and recess breaks at school, and children who demonstrate a higher level of competency in locomotor skills and object-control skills engage in more MVPA after-school. Object-control skill competency appears to be a better predictor of children's MVPA during school-based physical activity opportunities than locomotor skill competency. This suggests that improving movement skill competency, particularly object-control skills, among children is a potential avenue for promoting children's MVPA throughout the day. Findings from the current study substantially contribute to the understanding of physical activity behaviors in children and will assist in evidence-based school practice, polices and intervention design to increase physical activity.

Table 4.1 Descriptives and sex differences for children's background, fundamental movement skills and physical activity

	All			Girls			Boys			Sex difference
	n	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*p*
Background										
Age (years)	460	8.5	0.6	249	8.5	0.6	211	8.6	0.7	0.123
BMI-z score	458	0.75	1.25	248	0.67	1.22	210	0.84	1.29	0.156
SES[a]	460	3	2	249	3	2	211	3	2	0.879
FMS (raw)										
Locomotor skills	430	25.7	5.8	220	26.4	5.2	210	24.9	6.3	0.008*
Object-control skills	456	24.2	6.2	247	21.9	5.3	209	26.8	6.0	0.000*
Physical activity										
Total daily MVPA minutes	220	54.8	19.7	125	49.1	17.0	95	61.9	20.6	0.000*
Lunchtime MVPA minutes	325	5.4	3.8	185	4.6	3.3	140	6.5	4.1	0.000*
Recess MVPA minutes	325	5.8	4.4	185	4.8	4.1	140	7.0	4.5	0.000*
After-school MVPA minutes	325	15.5	11.7	185	14.4	13.2	140	16.9	9.3	0.039*

Abbreviations: FMS, fundamental movement skills; MVPA, moderate-to-vigorous physical activity; BMI, body mass index; SES, socio-economic status.

[a] Socio-Economic Indexes for Areas (SEIFA) index of relative socio-economic disadvantage (1 = most disadvantaged, 10 = least disadvantaged). *Significant difference between girls and boys, $p < 0.05$.

Table 4.2 Relationships between MVPA minutes and locomotor skills

	Total Daily MVPA					Lunchtime MVPA					Recess MVPA					After-school MVPA				
	n	**β**	**95% CI**	***r***	***p***	***n***	**β**	**95% CI**	***r***	***p***	***n***	**β**	**95% CI**	***r***	***p***	***n***	**β**	**95% CI**	***r***	***p***
Locomotor skills	213	0.010	0.004 0.016	0.15	0.002	314	0.010	-0.001 0.020	0.08	0.075	314	0.008	-0.002 0.018	0.06	0.108	314	0.016	0.003 0.029	0.13	0.014
BMI-z score	213	-0.031	-0.057 -0.006	-0.10	0.017	314	-0.023	-0.068 0.021	-0.04	0.303	314	-0.022	-0.065 0.020	-0.03	0.306	314	-0.045	-0.099 0.009	-0.08	0.103

Abbreviations: MVPA, moderate-to-vigorous physical activity; BMI, body mass index; SES, socio-economic status. All analyses were adjusted for sex, age, BMI-z score and SES and the effects of clustering by school. β values are logged therefore cannot be interpreted in the unit values of the variable.

Table 4.3 Relationships between MVPA minutes and object-control skills

	Total Daily MVPA					Lunchtime MVPA					Recess MVPA					After-school MVPA				
	n	**β**	**95% CI**	***r***	***p***	***n***	**β**	**95% CI**	***r***	***p***	***n***	**β**	**95% CI**	***r***	***p***	***n***	**β**	**95% CI**	***r***	***p***
Object-control skills	219	0.013	0.006 0.019	0.20	0.000	321	0.012	0.001 0.023	0.10	0.030	321	0.015	0.004 0.025	0.11	0.006	321	0.015	0.002 0.028	0.13	0.022
BMI-z score	219	-0.030	-0.055 -0.005	-0.09	0.021	321	-0.027	-0.070 0.016	-0.04	0.219	321	-0.020	-0.062 0.022	-0.03	0.343	321	-0.045	-0.098 0.008	-0.08	0.096

Abbreviations: MVPA, moderate-to-vigorous physical activity; BMI, body mass index; SES, socio-economic status. All analyses were adjusted for sex, age, BMI-z score and SES and the effects of clustering by school. β values are logged therefore cannot be interpreted in the unit values of the variable.

CHAPTER 5. PHYSICAL ACTIVITY AND SKILLS INTERVENTION: SCORES CLUSTER RANDOMISED CONTROLLED TRIAL

Preface:

This chapter presents the findings from the SCORES cluster randomised controlled trial, which was conducted to investigate the *Primary Aim* of this thesis (i.e., to evaluate the impact of the Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES) intervention on MVPA, cardiorespiratory fitness and FMS competency among children attending primary schools located in low-income communities).

The content in this chapter is the final version of the article which is published in the journal *Medicine and Science in Sports and Exercise*.

Citation:

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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 eight 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, body mass index 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, 5.0-20.5), overall FMS competency (4.9 units; 95% CI, -0.04-9.8), and cardiorespiratory fitness (5.4 laps; 95% CI, 2.3-8.6).

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.

5.1. Background

Physical inactivity has been described as a global pandemic [9]. 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 [9]. Schools have been identified as important settings for the promotion of physical activity among children [102], as they have the necessary resources and they provide access to populations at risk of being physically inactive, such as those from low socio-economic backgrounds [13, 18].

Numerous school-based interventions have been evaluated and evidence suggests that multi-component interventions are more effective than curriculum only approaches [106]. Although strong evidence exists for the effectiveness of school-based physical activity interventions [312, 313], studies rarely 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 [52].

FMS are considered the building blocks for movement and the primary school years are the optimal stage of life to develop proficiency [49]. For most, FMS competency does not occur naturally and is more likely to be achieved through quality instruction and active play experiences [49]. 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 [49]. 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 [51]. Although the health benefits gained from developing FMS competency in children is clear [51], competency among children is low [56, 58].

Socio-environmental factors (e.g., reduced access to physical activity facilities and resources, working parents and unsafe neighborhoods) [17, 314] and ineffective school-based strategies, including poor quality physical education (PE) [315], 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 [294], a 12-month school-based cluster randomized controlled trial (RCT) 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.

5.2. Methods

5.2.1. Study design and participants

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 RCT have been reported in detail elsewhere [294]. The design, conduct, and reporting of this cluster RCT adhered to the Consolidated Standards of Reporting Trials guidelines for group trials [316]. 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.

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 [295] 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,

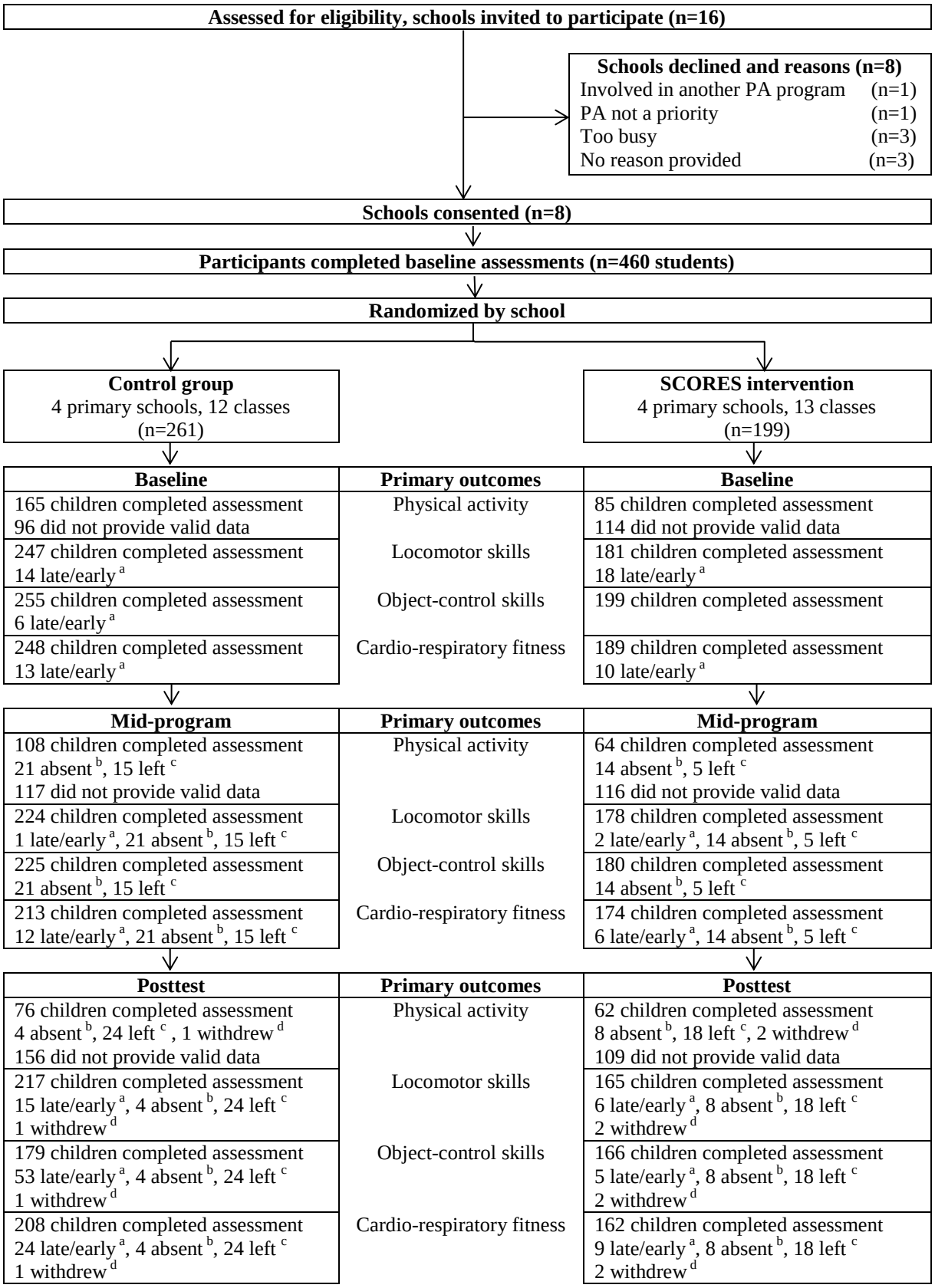

Figure 5.1 Study design and flow of participants through the study with primary outcome measures. [a]Children either arrived late at school or left school early on the assessment day; [b]children were absent on the assessment day; [c]children left the school; [d]children withdrew from the program.

home ownership, family support, family breakdown, family type, lack of wealth (no car or telephone), low income, Indigenous status and foreign birth [295]. 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).

5.2.2. Sample size calculation and randomization

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) [317], 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 [317]. Based on data from the Action Schools BC! (SD = 13) [318] and the KISS (ICC = 0.03) [317] 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 [63] 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).

After baseline assessments, the eight schools were match-paired (i.e., four 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.

5.2.3. Intervention

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 [294]. Briefly, the socio-ecological model [87] 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 a 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 interventions 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).

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 [319], the control schools were provided with equipment packs and a condensed version of the program following the posttest (12-month) assessments.

5.2.4. Assessments and measures

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.

5.2.4.1. Primary outcome measures

Physical activity: 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 [297], 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 [33, 320]. 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 [298].

Fundamental movement skills (FMS): FMS competency was assessed using the TGMD-2 [63] which has established validity and reliability in children [63]. 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 [63]. 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, 0.96-0.98) for inter-rater reliability and ranged from 0.94 (95% CI, 0.91-0.97) to 0.98 (95% CI, 0.97-0.99) for intra-rater reliability.

Cardiorespiratory fitness: Cardiorespiratory fitness was assessed using the 20 meter multistage fitness test [321]. 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.

5.2.4.2. Height and weight

Height was recorded to the nearest 0.1 cm using a portable stadiometer (Model no. PE087, Mentone Educational Centre, Australia). Weight was measured in light clothing without shoes using a portable digital scale (Model no. UC-321PC, A&D Company Ltd, Tokyo Japan) to the nearest 0.1 kg. Body mass index (BMI) was calculated using the standard equation (weight[kg]/height[m]2) and BMI z-scores were calculated using the 'LMS' method [300].

5.2.4.3. Demographic measures

Participating children completed a questionnaire to obtain demographic information including sex, age, language spoken at home, Aboriginal or Torres Strait Islander decent, ethnicity and suburb. The suburb of the child's residence was used to determine their socio-economic status using the SEIFA index of relative socioeconomic disadvantage [295].

5.2.4.4. Process evaluation

A detailed process evaluation was conducted and included 1) teacher and student attendance at workshops (i.e., percentage attendance), 2) student leadership accreditation (i.e., number of students who complete the workshop and satisfied the accreditation guidelines), 3) teacher satisfaction with professional learning workshops (using workshop evaluation questionnaires at the end of Phase 1), 4) parental involvement was determined using a process evaluation questionnaire completed by parents (e.g. reading newsletters and completion of home-based FMS tasks) and attendance at the parent evening, 5) teacher, student and parent satisfaction with all intervention components (using process evaluation questionnaires at the completion of the study), 6) compliance with PA policies was determined through interviews with school Principals (one interview at each of the four intervention schools was conducted. On average, the interviews lasted one hour), and 7) PE 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, wherein i) the teacher reviews previous lesson and ii) the teacher explains lesson focus; 2) warm-up, wherein i) lesson involves general movement-based warm-up and ii) warm-up includes dynamic and/or static stretching; 3) skill development, wherein i) a teacher or student demonstrates the skill, ii) lesson involves skill exploration, and iii) lesson involves guided discovery; 4) skill application, wherein i) lesson involves modified games and ii) lesson involves full-sided games; and 5) closure, wherein i) lesson includes cool down, ii) the 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.

5.2.5. Statistical analyses

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 [322]. 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 [317]. Intraclass correlation was calculated to compare the variation between school classes as a fraction of the total variance.

5.3. Results

Twenty-five classes in eight schools including 460 children (199 children in intervention group and 261 in control group) entered the study (Figure 5.1). Table 5.1 shows the baseline characteristics by treatment group. Table 5.2and Table 5.3 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 (χ^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.

Table 5.1 Characteristics of study sample

Characteristics	Control (n=261)	SCORES intervention (n=199)	Total (n=460)
Girls, No. (%)	142 (54.4)	107 (53.8)	249 (54.1)
Age, mean (SD), y	8.5 (0.6)	8.5 (0.7)	8.5 (0.6)
English language spoken at home, No. (%)	255 (97.7)	194 (97.5)	449 (97.6)
Aboriginal or Torres Strait Islander decent, No. (%)	32 (12.3)	32 (16.1)	64 (13.9)
Cultural background, No. (%)[a]			
Australian	230 (88.1)	167 (83.9)	397 (86.3)
Asian	2 (0.8)	1 (0.5)	3 (0.7)
European	9 (3.4)	12 (6.0)	21 (4.6)
African	2 (0.8)	4 (2.0)	6 (1.3)
Other[b]	17 (6.5)	15 (7.5)	32 (7.0)
Socioeconomic position, No. (%)[c]			
1-2	111 (42.5)	90 (45.2)	201 (43.7)
3-4	93 (35.6)	87 (43.8)	180 (39.1)
5-6	40 (15.3)	9 (4.5)	49 (10.6)
7-8	12 (4.6)	7 (3.5)	19 (4.1)
9-10	5 (1.9)	6 (3.0)	11 (2.4)
Weight status, No. (%)[d]			
Underweight	3 (1.2)	1 (0.5)	4 (0.9)
Healthy weight	150 (57.9)	122 (61.3)	272 (59.4)
Overweight	63 (24.3)	41 (20.6)	104 (22.7)
Obese	43 (16.6)	35 (17.6)	78 (17.0)

[a] One participant in the control group did not report their cultural background. [b] 'Other' refers to any cultural background other than Australian, Asian, European or African. [c] Socioeconomic position by population decile using Socio-Economic Indexes for Areas of relative socioeconomic disadvantage based on home postcode. 1 is the lowest and 10 is the highest. [d] Two participants in the control group were not measured for weight status.

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

Table 5.2shows 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.

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

Table 5.3 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.

5.3.3. Process outcomes

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 [323]), 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 four intervention schools had four 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.

5.4. Discussion

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.

Although 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 [324], 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 [317] (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 [141]. 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 [99], 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 et al. [124] demonstrated a similar physical activity maintenance effect over time, and suggested that increasing movement skills was the primary mechanism responsible for this result.

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 [304]. Effective intervention strategies identified in the review included teacher professional development focusing on class organization, management and instruction [304], all of which were key areas for professional development and lesson observations in the SCORES intervention [294]. 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.

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.

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 [325] 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 [326, 327], 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.

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. On the basis of 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.

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 [42]. Other high quality school-based interventions have also reported improvements in cardiorespiratory fitness [106, 328, 329]. 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.

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. Although 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.

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 [49]. 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 [49]. Current issues (i.e., inadequate teachers training, crowded curriculum) [141] 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 [13], especially in those who are at most risk (i.e., low socio-economic backgrounds), and the dire state of Australian primary school PE [315]. 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. Using 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.

5.4.1. Strengths and limitations

The strengths of this study include the cluster RCT 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 [330]. Children who are socially disadvantaged or who live in disadvantaged areas are significantly less likely to provide reliable accelerometer data [330]. Studies that measure only weekday or school-time (i.e., 9:00am-3:00pm 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.

5.5. Conclusions

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.

Table 5.2 Changes in primary outcomes measures and group differences at mid-program (6-months)

Measure	Control, Mean (SD)				P value[a]	Intervention, Mean (SD)				P value[a]	Adj. Diff. in Change (95% CI)[b]	P value[c]	ICC[d]
	Baseline		Mid-program			Baseline		Mid-program					
Physical Activity													
Total PA, counts/min	n=165	578.1 (162.6)	n=108	600.0 (136.8)	0.099	n=85	579.4 (218.6)	n=64	593.4 (172.1)	0.493	-5.4 (-80.6 to 69.7)	0.625	0.08
MVPA, percent	n=165	7.9 (2.7)	n=108	8.3 (2.5)	0.212	n=85	7.5 (2.7)	n=64	8.2 (2.9)	0.058	0.4 (-0.7 to 1.5)	0.471	0.13
MVPA, mins/day	n=165	57.8 (19.9)	n=108	59.4 (18.2)	0.489	n=85	52.5 (18.6)	n=64	59.0 (21.4)	0.020	5.7 (-3.1 to 14.6)	0.194	0.10
Within school MVPA, mins/day	n=213	28.0 (11.2)	n=130	27.5 (9.0)	0.428	n=112	23.3 (9.7)	n=100	30.1 (11.2)	0.005	4.1 (-2.4 to 10.6)	0.211	0.23
After-school MVPA, mins/day	n=213	15.7 (7.6)	n=130	17.2 (8.0)	0.063	n=112	15.2 (8.1)	n=100	18.2 (9.3)	0.017	1.0 (-2.3 to 4.4)	0.532	0.12
Weekend MVPA, mins/day	n=171	52.9 (27.0)	n=129	50.3 (27.1)	0.604	n=95	45.1 (24.9)	n=76	53.4 (28.0)	0.036	12.4 (-0.1 to 24.8)	0.051	0.10
Fundamental Movement Skills													
Locomotor skills	n=247	25.9 (5.8)	n=224	27.9 (4.9)	0.009	n=181	25.2 (5.7)	n=178	28.4 (6.4)	0.000	1.2 (-1.0 to 3.4)	0.260	0.08
Object-control skills	n=255	24.6 (6.0)	n=225	30.0 (6.1)	0.000	n=199	23.9 (6.4)	n=180	27.2 (7.1)	0.012	-1.8 (-5.7 to 2.2)	0.372	0.09
Overall FMS	n=242	50.5 (9.2)	n=224	57.9 (8.5)	0.000	n=181	49.5 (9.4)	n=178	55.8 (10.6)	0.001	-0.9 (-6.4 to 4.6)	0.737	0.10
Cardio-respiratory Fitness													
20m multistage fitness test, laps	n=248	23.8 (13.8)	n=213	27.1 (15.7)	0.007	n=189	21.2 (12.2)	n=174	25.4 (15.1)	0.001	0.8 (-2.0 to 3.7)	0.589	0.08

Abbreviations: PA, physical activity; MVPA, moderate-to-vigorous physical activity; FMS, fundamental movement skills; SD, standard deviation; CI, confidence interval; ICC, intraclass correlation coefficient. [a] Within group change over time. [b] Adjusted mean difference and 95% confidence intervals between SCORES intervention and control group after 6 months (intervention minus control); adjusted for sex, age, BMI z-score, SES and ethnicity in linear mixed model with random effect for school class. [c] Group-by-time interaction from mixed model that included baseline and 6-month data and covariates. [d] ICC for school class.

Table 5.3 Changes in primary outcomes measures and group differences at posttest (12-months)

Measure	Control, Mean (SD)				P value[a]	Intervention, Mean (SD)				P value[a]	Adj. Diff. in Change (95% CI)[b]	P value[c]	ICC[d]
	Baseline		Posttest			Baseline		Posttest					
Physical Activity													
Total PA, counts/min	n=165	578.1 (162.6)	n=76	502.0 (138.6)	0.000	n=85	579.4 (218.6)	n=62	553.3 (153.4)	0.412	54.2 (-10.3 to 118.6)	0.054	0.10
MVPA, percent	n=165	7.9 (2.7)	n=76	6.8 (2.4)	0.001	n=85	7.5 (2.7)	n=62	7.6 (2.5)	0.847	1.2 (0.2 to 2.3)	0.051	0.13
MVPA, mins/day	n=165	57.8 (19.9)	n=76	48.1 (17.5)	0.000	n=85	52.5 (18.6)	n=62	54.9 (20.1)	0.360	12.7 (5.0 to 20.5)	0.008	0.10
Within school MVPA, mins/day	n=213	28.0 (11.2)	n=127	25.0 (10.0)	0.350	n=112	23.3 (9.7)	n=86	26.6 (9.4)	0.180	4.5 (-1.0 to 9.9)	0.182	0.20
After-school MVPA, mins/day	n=213	15.7 (7.6)	n=127	11.4 (7.1)	0.000	n=112	15.2 (8.1)	n=86	15.4 (8.3)	0.811	4.6 (1.2 to 7.9)	0.028	0.15
Weekend MVPA, mins/day	n=171	52.9 (27.0)	n=80	34.4 (25.7)	0.000	n=95	45.1 (24.9)	n=66	43.1 (24.3)	0.485	14.5 (2.9 to 26.2)	0.034	0.06
Fundamental Movement Skills													
Locomotor skills	n=247	25.9 (5.8)	n=217	28.4 (4.9)	0.002	n=181	25.2 (5.7)	n=165	29.7 (5.8)	0.000	2.1 (-0.01 to 4.2)	0.144	0.07
Object-control skills	n=255	24.6 (6.0)	n=179	28.2 (6.7)	0.011	n=199	23.9 (6.4)	n=166	29.9 (5.9)	0.000	2.6 (-1.1 to 6.4)	0.062	0.10
Overall FMS	n=242	50.5 (9.2)	n=179	56.4 (9.0)	0.002	n=181	49.5 (9.4)	n=164	60.1 (9.0)	0.000	4.9 (-0.04 to 9.8)	0.045	0.11
Cardio-respiratory Fitness													
20m multistage fitness test, laps	n=248	23.8 (13.8)	n=208	25.8 (16.7)	0.295	n=189	21.2 (12.2)	n=162	28.6 (16.8)	0.000	5.4 (2.3 to 8.6)	0.003	0.09

Abbreviations: PA, physical activity; MVPA, moderate-to-vigorous physical activity; FMS, fundamental movement skills; SD, standard deviation; CI, confidence interval; ICC, intraclass correlation coefficient. [a] Within group change over time. [b] Adjusted mean difference and 95% confidence intervals between SCORES intervention and control group from baseline to 12 months (intervention minus control); adjusted for sex, age, BMI z-score, SES and ethnicity in linear mixed model with random effect for school class. [c] Group-by-time interaction from mixed model that included baseline, 6-month and 12-month data and covariates. [d] ICC for school class.

CHAPTER 6. IMPROVEMENTS IN FUNDAMENTAL MOVEMENT SKILL COMPETENCY MEDIATE THE EFFECT OF THE SCORES INTERVENTION ON PHYSICAL ACTIVITY AND CARDIORESPIRATORY FITNESS IN CHILDREN

Preface:

This chapter presents the results of a mediation analysis, which was conducted to investigate *Secondary Aim 3* of this thesis (i.e., to determine if changes in FMS competency and perceived competence mediate the effect of the SCORES intervention on MVPA and cardiorespiratory fitness among children attending primary schools located in low-income communities).

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Abstract

Background: Studies have identified a positive association between fundamental movement skill (FMS) competency and physical activity in children; however the causal pathways have not been established.

Objective: To determine if changes in FMS competency mediated the effect of the SCORES intervention on physical activity and cardiorespiratory fitness in children.

Methods: Eight primary schools (25 classes) and 460 children (aged 8.5±0.6, 54% girls) were randomized to the SCORES intervention or control group for the 12-month study. Outcomes were accelerometer-determined moderate-to-vigorous-physical-activity (MVPA) and cardiorespiratory fitness. Hypothesized mediators were actual FMS competency and perceived sport competence. Mediation analyses were conducted using multi-level linear analysis in MPlus.

Results: From the original sample, 138 (30.0%) and 370 (80.4%) children provided useable physical activity and cardiorespiratory fitness data at post-test assessments. There were significant treatment effects for locomotor skills and overall FMS. Changes in MVPA were associated with changes in object-control skills, overall FMS and perceived competence. Overall FMS had a significant mediating effect on MVPA (AB = 2.09, 95% CI 0.01-4.55). Overall FMS (AB = 1.19, 95% CI 0.002-2.79) and locomotor skills (AB = 0.74, 95% CI 0.01-1.69) had a significant mediating effect on cardiorespiratory fitness.

Conclusion: Actual but not perceived movement skill competency mediated the effect of the SCORES intervention on physical activity and cardiorespiratory fitness.

6.1. Introduction

The physical, social, cognitive and psychological benefits of regular participation in physical activity for children are well established [3]. Moreover, high cardiorespiratory fitness in children is associated with a reduction in the prevalence of cardiovascular risk factors [35, 331]. However, many children do not participate in physical activity of adequate volume and intensity to acquire the associated physical and psychological health benefits [9]. These physical activity and cardiorespiratory fitness trends in childhood often track into adolescence and adulthood [38, 332, 333], emphasizing the need to find effective strategies for increasing physical activity and cardiorespiratory fitness in young people.

The school setting is an ideal environment for the promotion of physical activity and cardiorespiratory fitness [102, 103], and numerous school-based physical activity and cardiorespiratory fitness interventions have been evaluated [106]. Although school-based interventions have achieved some level of success [106], there is limited understanding on the causal mechanisms of behavior change. Mediation analyses may assist in explaining intervention effects by identifying the mechanisms of behavior change. In physical activity interventions, mediators are the intervening causal variables necessary to complete the pathway from the intervention to the outcome of interest [71]. Despite its importance, limited studies have assessed mediators of physical activity and cardiorespiratory fitness in interventions among children, and there is large variability in the design and quality of these studies [81, 82]. In a recent review, on the basis of limited studies, self-efficacy and intention were found to be the most relevant mediators for physical activity interventions [82]. Indications for a mediated effect of self-regulation, intrinsic motivation, enjoyment, perceived benefits, proxy efficacy and autonomy support on physical activity interventions were also found. However, the majority of studies were conducted in secondary schools. In addition, many studies [81, 82] have used self-report measures of physical activity, which are limited by children's ability to accurately recall their behaviors and generally have low levels of validity and reliability in youth populations [14]. The review identified that more high-quality research into relevant mediators in children is needed [82].

Fundamental movement skills (FMS) are considered the 'building blocks' for movement in a range of sports and physical activities. FMS include locomotor (e.g., running and jumping), object-control (e.g., throwing and kicking) and stability (e.g., balancing and twisting) skills [49]. In a recent review, FMS competency was found to be significantly associated with physical activity and cardiorespiratory fitness in youth [51]. In addition, lack of perceived competence in the physical domain is associated with lower levels of physical activity in children and adolescents [334-336]. Indeed, Stodden et al. [336] have proposed a model suggesting that the development of actual FMS competency is a primary underlying mechanism that determines physical activity engagement. While they acknowledge that actual FMS interacts with other factors such as perceived competence and health-related fitness, they contend that actual competence is largely responsible for participation and persistence in physical activity among young people [336]. Although numerous cross-sectional and longitudinal studies have identified a positive association between FMS competency and physical activity and cardiorespiratory fitness in young people [51], the causal pathways of influence have not been established in experimental studies.

Therefore, the primary aim of the current study was to determine if changes in FMS competency mediated the effect of the Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES) intervention on physical activity and cardiorespiratory fitness in children attending primary schools in low-income communities. The secondary aim of the study was to determine if changes in perceived competence mediated the effect of the SCORES intervention on physical activity and cardiorespiratory fitness in children attending primary schools in low-income communities. In a cluster randomized controlled trial (RCT), the SCORES intervention resulted in significant group-by-time effects for moderate-to-vigorous physical activity (MVPA), cardiorespiratory fitness and overall FMS competency, which have been described in detail elsewhere [337].

6.2. Methods

6.2.1. Study design

The design and methods of the SCORES cluster randomized controlled trial (RCT) have been reported in detail elsewhere [294]. The design, conduct, and reporting of this cluster RCT adhered to the Consolidated Standards of Reporting Trials guidelines for group trials [316] and was registered with the Australia and New Zealand Clinical Trials registry (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 and study participants provided written informed consent. Data for this study were used from the baseline (conducted February through March 2012) and post-test (12-months post baseline; conducted February through March 2013) assessments.

6.2.2. Setting and participants

Eight low socio-economic status (SES) government primary schools (25 classes) from the Newcastle area, NSW, Australia identified using the Socio-Economic Indexes for Areas (SEIFA) index of relative socioeconomic disadvantage [295] with a SEIFA index of ≤ 5 (lowest 50%) consented to participate (50% consent rate). A total of 460 students (Grades 3 and 4; aged 7 to 10 years) at the study schools consented to participate (78% consent rate). Following baseline assessments, the eight schools were match-paired (i.e. four pairs of schools) based on their size and SES (based on post-code of school). Pairs of schools were then randomised to control or intervention conditions by an independent researcher using a computer-based random number producing algorithm. Assessors were blind to treatment allocation at baseline but not at follow-up assessments.

6.2.3. Study arms

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 [294]. Briefly, the socio-ecological model [87] provided a framework for the intervention, and the

intervention components included teacher professional learning, student leadership, school committee and physical activity policies, provision of physical activity equipment, parental engagement (newsletters, parent evening, and FMS homework) and school-community sport and physical activity links. The control schools were requested to follow their usual physical education and school sport program.

6.2.4. Outcomes

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 to standardise procedures and for quality assurance. The same research assistants were used across all time-points.

6.2.4.1. Physical activity

Physical activity was assessed using triaxial ActiGraph GT3X+ accelerometers (ActiGraph, LLC, Fort Walton Beach, FL). Trained research assistants, adhering to standardised accelerometer protocols [297], fitted the accelerometers and explained the monitoring procedures to participants. Participants wore accelerometers during waking hours for seven consecutive days, except while bathing and swimming. MeterPlus version 4.3 software (Santech Inc., San Diego, US) was used to analyse 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 [33]. Non-wear time was defined as strings of consecutive zeroes equating to 20 minutes [33]. 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 [298].

6.2.4.2. Cardiorespiratory fitness

Cardiorespiratory fitness was assessed using the 20 meter Multistage Fitness Test [46]. The 20 meter Multistage Fitness Test is a valid and reliable test to assess cardiorespiratory fitness in children [44]. Participants were required to run back and forth between two lines over a 20 meter 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 required to run in a straight line and to place one foot over the 20 meter 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 meter laps completed to provide a continuous variable for analysis.

6.2.4.3. Hypothesized mediators

Fundamental movement skill competency: FMS competency was assessed using the Test of Gross Motor Development 2 (TGMD-2) [63]. This test has been established as a valid and reliable assessment of FMS competency [63]. The TGMD-2 includes six locomotor (i.e., run, gallop, hop, leap, horizontal jump and 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 added to obtain a raw locomotor subtest score and a raw object-control subtest score, which were then added to obtain a raw overall FMS score [63]. Inter-rater reliability (98% agreement rate) and intra-rater reliability (97% to 99% agreement rate) were established for FMS scores 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.

Perceived sport competence: Perceived sport competence was assessed using the perceived competence sub-scale from Harter's Self-Perception Profile (SPP) [266]. The SPP uses a four-choice structured alternative format to reduce socially desirable responses. Participants first decide which of the two statements best describes them and then choose whether the statement is '*sort of true*' or '*really true*' for them. 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.

6.2.4.4. Demographics and weight status

Participants completed a questionnaire to obtain demographic information including sex, age, and suburb. The suburb of the child's residence was used to determine their SES using the SEIFA index of relative socioeconomic disadvantage [295]. Height was recorded to the nearest 0.1 cm using a portable stadiometer (Model no. PE087, Mentone Educational Centre, Australia). Weight was measured in light clothing without shoes using a portable digital scale (Model no. UC-321PC, A&D Company Ltd, Tokyo Japan) to the nearest 0.1 kg. Body mass index (BMI) was calculated using the standard equation (weight[kg]/height[m]2) and BMI z-scores were calculated using the 'LMS' method [300].

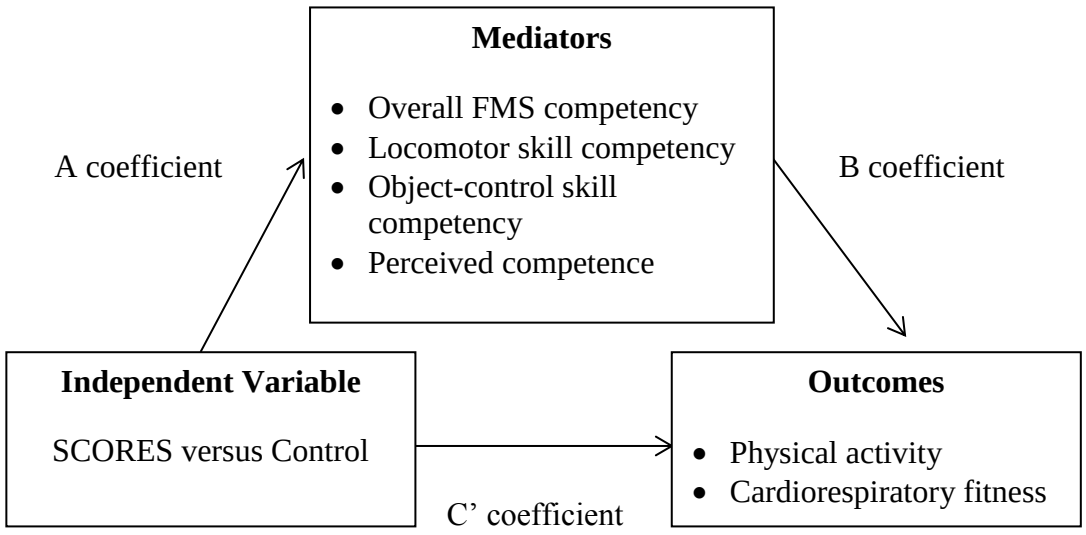

Figure 6.1 Mediation model showing the mediators of the effect of the SCORES intervention on physical activity and cardiorespiratory fitness

6.2.5. Statistical analyses

IBM SPSS Statistics for Windows (Version 20, SPSS Inc., IBM Corp., Armonk, NY) was used to analyse the difference between groups at baseline, and differences between those who completed the study and those who did not. Intervention effects and single mediation analyses were conducted using multi-level linear analysis in MPlus (Version 7.2, Muthen and Muthen). Two levels were defined in the multi-level analyses: 1) student and 2) class. All analyses were adjusted for participants' sex, age, BMI z-score, SES and baseline values, which were included as covariates. Analyses were conducted for participants who provided useable data at baseline and post-test.

The product-of-coefficient mediation analysis was conducted and consisted of three stages: Stage 1, the action theory test, was calculated by regressing the hypothesized mediators onto treatment condition (A coefficient). Stage 2, the conceptual theory test, involved regressing physical activity and cardiorespiratory fitness onto treatment condition and the hypothesized mediators (B coefficient). This model also generates the direct effect of the intervention on physical activity and cardiorespiratory fitness after controlling for the mediators (C´ coefficient). In stage 3, the R mediation package developed by Tofighi and MacKinnon [338] was used to test the significance of the product-of-coefficients (AB) by computing the confidence intervals for the mediated effect on the basis of the distribution-of-product method (Figure 6.1). This approach is recommended for small samples and has more power than traditional mediation tests, such as the Baron and Kenny test, which requires a much larger sample size [339]. For a variable to satisfy the criteria for mediation, the 95% confidence intervals for the product-of-coefficients (AB) must not include zero. The proportion of the total effect that was mediated was also calculated [AB/(C' + AB)].

6.3. Results

6.3.1. Overview

Eight schools (25 classes) including 460 children (199 children in intervention group and 261 in control group) participated in the SCORES study. The mean (SD) age of

participants was 8.5 (SD = 0.6) years, 54.1% of the sample were girls and 97.6% spoke English at home. Retention rate at post-test for physical activity was 30.0% (265 did not provide valid data, 42 participants left the schools, 12 participants absent and 3 participants withdrew from the study), cardiorespiratory fitness was 80.4% (42 participants left the schools, 33 arrived late or left school early on day of assessment, 12 participants absent and 3 participants withdrew from the study), locomotor skills was 83.0% (42 participants left the schools, 21 arrived late or left school early on day of assessment, 12 participants absent and 3 participants withdrew from the study), and object-control skills were 75.0% (58 arrived late or left school early on day of assessment, 42 participants left the schools,12 participants absent and 3 participants withdrew from the study). Participants with a baseline assessment but no post-test assessment did not differ from the remaining participants in terms of sex, age, physical activity, object-control skills or cardiorespiratory fitness (all $p > 0.05$). Participants who did not complete post-test assessment had lower locomotor skill competency at baseline ($p = 0.002$) compared to those who completed post-test assessments.

Intervention effects for physical activity, cardiorespiratory fitness and FMS competency have been reported previously [337]. In summary, using linear mixed models, at post-test (12-months post baseline), significant group-by-time interaction effects were found for daily moderate-to-vigorous physical activity (MVPA) (adjusted mean difference, 12.7 MVPA mins/day; SE, 3.8; $p = 0.008$), cardiorespiratory fitness (5.4 laps; SE, 1.6; $p = 0.003$), and overall FMS competency (4.9 units; SE, 2.4; $p = 0.045$). No significant group-by-time effects were found for locomotor skills, object-control skills or perceived sport competence.

6.3.2. Mediation effects for physical activity as the outcome

6.3.2.1. Action theory test

Mediation results for physical activity (MVPA minutes) as the outcome are presented in Table 6.1. The action theory test revealed a significant beneficial intervention effect for locomotor skills (A = 1.76, SE = 0.88, $p = 0.044$) and overall FMS (A = 4.09, SE = 2.08, $p = 0.049$). There were no significant effects for object-control skills or perceived competence ($p > 0.05$).

6.3.2.2. Conceptual theory test

The results from the conceptual theory test showed a significant relationship between post-test object-control skills (B = 0.86, SE = 0.15, p = 0.000), overall FMS (B = 0.51, SE = 0.10, p = 0.000), perceived sport competence (B = 0.48, SE = 0.36, p = 0.027) and MVPA levels, adjusting for baseline. The relationship between locomotor skills and MVPA levels approached significance (B = 0.49, SE = 0.26, p = 0.056).

6.3.2.3. Significance test of mediated effect

Overall FMS competency mediated the effect of the intervention on MVPA (AB=2.09, 95% CI 0.01 to 4.55, proportion=23%). Locomotor skills, object-control skills and perceived sport competence did not satisfy the criteria for mediation.

6.3.3. Mediation effects for cardiorespiratory fitness as the outcome

6.3.3.1. Action theory test

Mediation results for cardiorespiratory fitness as the outcome are presented in Table 6.2. The action theory test revealed a significant beneficial intervention effect for locomotor skills (A = 1.76, SE = 0.88, p = 0.044) and overall FMS (A = 4.09, SE = 2.08, p = 0.049). There were no significant effects for object-control skills or perceived competence (p > 0.05).

6.3.3.2. Conceptual theory test

The results from the conceptual theory test showed a significant relationship between post-test locomotor skills (B = 0.42, SE = 0.11, p = 0.000), overall FMS (B = 0.29, SE = 0.08, p = 0.000), perceived sport competence (B = 0.55, SE = 0.15, p = 0.000) and cardiorespiratory fitness, adjusting for baseline. The relationship between object-control skills and cardiorespiratory fitness approached significance (B = 0.24, SE = 0.12, p = 0.050).

6.3.3.3. Significance test of mediated effect

Overall FMS competency (AB = 1.19, 95% CI 0.002 to 2.76, proportion=22%) and locomotor skills (AB = 0.74, 95% CI 0.01 to 1.69, proportion=15%) mediated the

effect of the intervention on cardiorespiratory fitness. Object-control skills and perceived sport competence did not satisfy the criteria for mediation.

6.4. Discussion

The primary aim of this study was to determine if changes in FMS competency mediated the effect of the SCORES intervention on physical activity and cardiorespiratory fitness in children attending primary schools in low-income communities. This study demonstrated that overall FMS competency mediated the effect of the SCORES intervention on physical activity and cardiorespiratory fitness. To the authors' knowledge, this is the first study to explore the mediating effects of FMS competency within the context of a successful physical activity intervention.

SCORES was a school-based multi-component intervention that resulted in a significant intervention effect for children's MVPA, cardiorespiratory fitness and FMS competency [337]. These results provide further evidence for the effectiveness of school-based multi-component intervention strategies that combine educational, curricular and environmental elements in the promotion of physical activity and cardiorespiratory fitness in children. Such interventions are built on the assumption that changes at the individual, social or environmental levels will result in behaviour change. However, few studies conduct mediation analyses to identify the causal mechanisms [81, 106]. Understanding the mechanisms through which interventions achieve success is of utmost importance. Particularly, as multi-component interventions can be very intensive, it is important to identify which components were effective in achieving the outcome. This will assist in informing researchers on which intervention components to focus on in order to design effective and efficient interventions.

FMS have long been considered the foundation of an active lifestyle [49]. However, often these claims are based on cross-sectional studies and a limited number of longitudinal studies showing the significant positive association between FMS competency and physical activity, and FMS competency and cardiorespiratory fitness in youth [51]. While strong evidence does exist for this relationship as synthesised in a recent systematic review [51], the limitation of cross-sectional

studies is that the direction of the relationship cannot be inferred (i.e., whether higher FMS competency increases a child's physical activity or whether greater participation in physical activity improves FMS competency). Moreover, the lack of quality longitudinal and experimental studies provides a further limitation [325]. For example, one intervention study found children in the FMS intervention group at post-test had higher levels and greater enjoyment of physical activity; however the analysis did not test whether changes in physical activity were a result of increased FMS [340]. Another intervention that resulted in post-test FMS improvement [341], had sustained skill effects three years later [342], but no physical activity differences between control and intervention children. This could be because physical activity was only assessed at the three year follow-up, which meant baseline and post-test values could not be adjusted for in the analysis.

Findings from the current study suggest that improvements in overall FMS competency may act as a causal mechanism for physical activity behaviour change and subsequent improvements in cardiorespiratory fitness among children. It is plausible to suggest that developing FMS is a very important component of physical activity engagement. That is, through learning to move, children are able to more successfully participate in a variety of physical activities and in turn improve their cardiorespiratory fitness. This finding supports Stodden and colleague's conceptual model that contends that the development of actual FMS competency is a primary underlying mechanism that determines physical activity engagement [336]. While Stodden et al. [336] support the role of psychological factors such as perceived competence that are included in many theoretical models [343, 344], they suggest that the most important determinant of behaviour change is actual FMS competency. While they acknowledge that actual FMS interacts with other factors such as perceived competence and health-related fitness, they argue that actual competence is important is its own right and is largely responsible for engagement and persistence in physical activity among young people. They propose that across developmental time, if a child does not have actual FMS competency, perceptions of competence will decrease when that child is more accurately able to evaluate their competency level, which will in turn influence their decision to participate in physical activity [336].

The findings in the current study confirm our hypothesis that improving children's FMS will increase their participation in physical activity and increase their cardiorespiratory fitness. The capacity to participate in physical activity of moderate-to-vigorous intensity on a regular basis is crucial to changing children's cardiorespiratory fitness levels [328]. Children with improved FMS competency may increase their time in MVPA and persevere with activities that require high levels of cardiorespiratory fitness resulting in cardiorespiratory fitness adaptations [345]. Interestingly, locomotor skills mediated the effect of the intervention on cardiorespiratory fitness but not physical activity. This finding is in contrast to a previous longitudinal study which found object-control competency predicted cardiorespiratory fitness, but locomotor competency did not [346]. It would seem that many cardiorespiratory fitness promoting activities (e.g., ball sports) are dependent on a certain level of object-control skill competency, rather than locomotor skill competency for participation. However, locomotor skill competency has been recognized as an important determinant of cardiorespiratory fitness. One study found that all six FMS (sprint run, vertical jump, overarm throw, catch, forehand strike and kick) were significantly associated with cardiorespiratory fitness; however the locomotor skill of sprint run had the highest correlation of any skill [347]. Similarly, the sprint run and the vertical jump were also related to cardiorespiratory fitness in children [348].

It is imperative that causal mechanisms are understood in childhood to assist in preventing the decline in physical activity and cardiorespiratory fitness typically observed during adolescence [42, 349]. The mediation findings from this study provide a rationale for the inclusion of strategies to develop FMS competency in interventions and educational contexts in order to promote physical activity and cardiorespiratory fitness in children. A major focus of the SCORES intervention was developing children's FMS. A number of intervention strategies were employed including teacher professional learning and lesson observations to improve the quality of physical education, implementation of school physical activity policies, weekly FMS homework and student leadership tasks to promote FMS in the school [294]. Process evaluation data reported previously, indicated an improvement in the quality of the intervention schools physical education, and good adherence to the

FMS homework, student leadership tasks and some physical activity policies [337]. This comprehensive approach to improve school-based physical education and physical activity is important, given the widely published deficiencies identified in the quality of primary school physical education programs [141].

Perceived sport competence did not mediate physical activity or cardiorespiratory fitness in this study. This is a surprising finding considering the strong support for perceived competence as an important correlate of physical activity and cardiorespiratory fitness in youth [334, 350] and its inclusion in a number of behavior change theories [97, 351]. Perceived competence is generally referred to as confidence to perform sport, outdoor games and physical activities [352]. It is proposed that perceived competence is central to a child's motivation which in turn influences whether a child will maintain engagement and affects physical activity participation choices [343]. A recent systematic review found perceived competence had the strongest association with physical activity behavior out of all the self-concept domains examined [335]. There is limited investigation of the mediating effects of perceived competence in school-based physical activity interventions for children. Similar to the results found in this study, van Stralen et al. [84] found that perceived competence did not meet the criteria for mediation in their physical activity intervention among primary school-aged children. Interestingly, in contrast to these results, perceived competence has been shown to be an important casual mechanism in physical activity interventions in adolescents [53, 353]. The strength of the relationship between perceived competence and physical activity increases as children move into adolescence [335] and their cognitive abilities improve and they become more aware and concerned about their physical abilities [336].

Although perceived competence did not meet the criteria for mediation, changes in perceived competence were significantly associated with changes in physical activity and cardiorespiratory fitness. This indicates that perceived competence holds potential to be included in future physical activity and cardiorespiratory fitness interventions in children. The lack of mediation findings for perceived competence could be explained by a number of reasons. Firstly, the SCORES intervention was successful in improving children's actual, but not their perceived competence.

Improving the quality of physical education lessons was the main strategy used to improve children's perceived sport competence. Teachers were encouraged to teach FMS using the 'Supportive Active Autonomous Fair Enjoyable' (SAAFE) teaching principles [294]. These principles utilised a mastery learning climate focusing on opportunities for the children to succeed and be encouraged to individually improve, which aimed to increase levels of perceived competence. However, the strategies to increase perceived competence in the SCORES intervention were not well developed and additional strategies may be needed to improve children's perceptions of their movement skill competence. In addition, the challenges of measuring perceived competence in children may have restricted our ability to detect changes in this construct. Children may not possess the cognitive skills to accurately assess their physical abilities. Consequently, children often report exaggerated levels of perceived competence [354, 355], which may also explain the limited mediation findings in this study.

Findings in this study add to the limited but growing body of evidence examining the mediators of successful school-based physical activity interventions in children. Previous mediation studies have primarily focused on the investigation of psychological and social mediators, with strong evidence for self-efficacy as a mediator of school-based physical activity interventions [82]. Combined, these findings will assist in understanding the underlying mechanisms of behavior change in order to strengthen effective intervention components and eliminate or adapt ineffective components. However, as this study is the first mediation analyses of FMS in a physical activity intervention, further research is needed to replicate the importance of FMS as a mediator and how this will be moderated by age and population group. Moreover, further research is needed to examine the mediating effects of perceived competence and how this may be moderated by age, in order to accurately understand its role in physical activity and cardiorespiratory fitness promotion.

6.4.1. Study strengths and limitations

The strengths of this study include being the first study to explore the mediating effects of FMS competency in a physical activity intervention in children, the cluster

RCT design, the objective measures of physical activity (accelerometers) and cardiorespiratory fitness, a comprehensive battery of movement skills (both locomotor and object control skills), adjustment of all analyses for confounders, and a high level of participant retention for cardiorespiratory fitness and FMS. However, a limitation that should be noted is that despite employing a variety of strategies (e.g., text messages and prizes) to increase accelerometer monitoring compliance, only a small number of participants provided useable accelerometer data at baseline (54.3%) and post-test (30.0%). Accelerometers are deemed to be the best practice for assessing change in physical activity; however, wear compliance appears to be a consistent challenge for physical activity researchers. Adherence to monitoring protocols is frequently poor, particularly among children of low-SES, with children significantly less likely to provide reliable accelerometer data if they are socially disadvantaged or reside in disadvantaged locations [330]. Compliance levels in this study appear to be comparable with other studies investigating population groups from low-income communities [330]. Furthermore, the variation in wear time criteria can also affect compliance rates. Studies that have a reduced inclusion criteria (i.e., any three days), or measure only weekday or school time (Monday to Friday 9:00am-3:00pm) physical activity tend to attain higher rates of compliance. Studies with reduced inclusion criteria tend to have higher compliance than reported in this study; however may not provide a comprehensive representation of the participants' 'usual' weekly physical activity as the three weekdays and one weekend criteria that was used in this study [33]. Often, higher weekday or school time compliance is due to teachers being responsible for administering the accelerometers during the school day, consequently decreasing the challenges of poor compliance outside the school environment. Alternatively, the use of wrist-worn accelerometers may lead to increased rates of compliance as they may be more acceptable for children, and issuing timely reminders throughout the research period, in particular among low-SES populations may be crucial to increase compliance.

6.5. Conclusions

This study has demonstrated that the SCORES school-based physical activity intervention for children which resulted in significant group-by-time interaction

effects for physical activity and cardiorespiratory fitness was mediated by actual, but not perceived movement skill competency. This provides evidence for the inclusion of FMS development as a mechanism of behaviour change and, thus, a strategy that should be included in interventions aimed at increasing children physical activity and cardiorespiratory fitness.

Table 6.1 Action theory test, conceptual theory test and significance of the mediated effect on physical activity (MVPA minutes) at post-test (12-months)

Hypothesized mediators	Direct effect		Action theory test			Conceptual theory test			Significance of mediated effect		Proportion (%)
	n	C' (SE)	n	A (SE)	*p* value	n	B (SE)	*p* value	AB	95% CI	AB/(C' + AB)
Locomotor skills	97	8.88 (2.49)	352	1.76 (0.88)	0.044	97	0.49 (0.26)	0.056	0.86	-0.12 to 2.44	9%
Object control skills	90	7.71 (2.02)	341	1.86 (1.57)	0.238	90	0.86 (0.15)	0.000	1.60	-1.04 to 4.50	17%
Overall FMS	86	7.01 (1.95)	314	4.09 (2.08)	0.049	86	0.51 (0.10)	0.000	2.09	0.01 to 4.55	23%
Perceived competence	101	9.29 (2.23)	375	0.06 (0.69)	0.934	101	0.48 (0.36)	0.027	0.03	-0.84 to 0.95	<1%

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; MVPA, moderate-to-vigorous physical activity.

Table 6.2 Action theory test, conceptual theory test and significance of the mediated effect on cardiorespiratory fitness at post-test (12-months)

Hypothesized mediators	Direct effect		Action theory test			Conceptual theory test			Significance of mediated effect		Proportion (%)
	n	C' (SE)	n	A (SE)	*p* value	n	B (SE)	*p* value	AB	95% CI	AB/(C' + AB)
Locomotor skills	327	4.27 (1.55)	352	1.76 (0.88)	0.044	327	0.42 (0.11)	0.000	0.74	0.01 to 1.69	15%
Object control skills	313	4.72 (1.63)	341	1.86 (1.57)	0.238	313	0.24 (0.12)	0.050	0.45	-0.30 to 1.58	9%
Overall FMS	296	4.14 (1.61)	314	4.09 (2.08)	0.049	296	0.29 (0.08)	0.000	1.19	0.002 to 2.76	22%
Perceived competence	339	4.49 (1.48)	339	0.08 (0.49)	0.864	339	0.55 (0.15)	0.000	0.05	-0.51 to 0.62	1%

Note. C', unstandardized regression coefficient of the intervention predicting cardiorespiratory fitness 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 cardiorespiratory fitness; AB, product-of-coefficients estimate; SE, standard error; 95% CI, 95% confidence interval.

CHAPTER 7. PSYCHOLOGICAL, SOCIAL AND PHYSICAL ENVIRONMENTAL MEDIATORS OF THE SCORES INTERVENTION ON PHYSICAL ACTIVITY AMONG CHILDREN LIVING IN LOW-INCOME COMMUNITIES

Preface:

This chapter presents the results of a mediation analysis, which was conducted to investigate *Secondary Aim 4* of this thesis (i.e., to determine if changes in individual, social and physical environmental constructs mediate the effect of the SCORES intervention on MVPA among children attending primary schools located in low-income communities).

The content in this chapter is the version of the article which is currently under review in the journal *Journal of Behavioral Medicine*.

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Abstract

Background: Limited studies have investigated the potential mediating effects of psychological, social and environmental variables in school-based physical activity interventions in children.

Purpose: To determine if changes in socio-ecological constructs mediated the effect of the SCORES school-based intervention on accelerometer-determined physical activity among children.

Methods: Primary school children were randomly assigned the SCORES multi-component intervention or control group for the 12-month study. The outcome was total moderate-to-vigorous physical activity (MVPA) (accelerometers). Hypothesised mediators measured in children via questionnaire were enjoyment of physical activity, perceived sport competence, and perceived social support. Hypothesised mediators measured in parents via questionnaire were social support from family, 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 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), perceived access to physical activity opportunities in the local community (B = 0.60, SE = 0.26, p = 0.021), and changes in total MVPA. 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 0.06-3.95, proportion 13%).

Conclusion: Perceived access to physical activity opportunities in the local community is a potential mechanism of physical activity behaviour change in children and mediated the effect of the SCORES intervention on objectively measured physical activity.

7.1. Background

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 [9, 10]. The school setting has been identified as an important setting for the promotion of physical activity in children [102, 103] and a number of school-based interventions aimed at increasing children's physical activity levels have been evaluated [105-107]. Recent reviews have shown that high quality, multi-component approaches in schools can increase young people's physical activity [106, 107, 356]. While evaluating the effectiveness of school-based interventions is necessary, investigation of potential mediating variables is vital for systematic progression of physical activity research and to further our understanding of how interventions work [71, 81, 357].

Mediation analysis can be used to determine whether an intervention was successful via the hypothesised 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 [71]. While primary school physical activity interventions are common, large scale, multi-component interventions are rare, and limited have investigated the hypothesised mediators of intervention effects. 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 [82]. 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 behaviour change in children [81, 82]. Of note, only four studies [83, 358-360] have examined the impact of hypothesised 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 [86]. Moreover, there is a distinct lack of studies investigating environmental mediating variables [82]. The limited studies investigated the mediating effects of

access to facilities among adolescent girls [359] and the perceived school environment among children [83], 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 [78], and the importance of the physical environment is noted in health behaviour change models [87, 88].

The socio-ecological model, which highlights the important role of the social and physical environment in determining behaviour [87], 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 [294]. 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 [337]. Behaviour change strategies for the intervention were guided by an integrated model involving elements of self-determination theory [95, 96] and competence motivation theory [97, 351].

The integrated model used in the SCORES intervention, proposed that children who have high levels of perceived and actual movement skill competency, and receive social support from significant others in their life, will enjoy physical activity and seek opportunities to be physically active in the future [294]. The mediation effects of actual movement skill competency have been reported previously [361], and found that fundamental movement skill competency mediated the effect of the SCORES intervention on physical activity behaviour. Therefore, the primary aim of the current study 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.

7.2. Methods

7.2.1. Study design

The SCORES intervention was evaluated using a cluster randomised controlled trial (RCT). The design, conduct, and reporting of this cluster RCT adhered to the Consolidated Standards of Reporting Trials guidelines for group trials [316]. 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 and study participants provided written informed consent. A detailed description of the design and methods of the SCORES cluster RCT has been reported previously [294]. 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.

7.2.2. 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 [295] 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) consented to participate (78% consent rate).

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 randomised 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.

7.2.3. Study arms

The SCORES intervention has been described in detail previously [294]. 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 [87] provided a framework for the intervention and behaviour change strategies were guided by self-determination theory [95, 96] and competence motivation theory [97, 351]. 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 organisations visited schools during physical education/ school sport to promote community sporting links). The intervention strategies were aligned with socio-ecological mechanisms of behaviour change, which are summarized in Table 7.1

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

7.2.4. 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 standardise procedures and for quality assurance. The same research assistants and instruments were used at all time-points.

7.2.4.1. 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 standardised accelerometer protocols [297]. Children were required to wear accelerometers during waking hours for seven consecutive days, except while bathing and swimming. Accelerometer data was analysed 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 [33]. Non-wear time was defined as strings of consecutive zeroes equating to 20 minutes [33]. 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 [298].

7.2.4.2. Hypothesised mediators

An overview of the hypothesised mediators and the scale descriptions is provided in Table 7.1.

Enjoyment: Children completed the Physical Activity Enjoyment Scale (PACES) [362] 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 7.1).

Perceived sport competence: Children completed the perceived competence sub-scale from Harter's Self-Perception Profile (SPP) [266] 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 α = 0.69 (Table 7.1).

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 [363]. Children reported the social support for physical activity they receive from teachers using an existing scale [276]. Each scale contained five items and all scales utilized a 5-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 α = 0.85, social support from peers α = 0.65 and social support from teachers α = 0.75 (Table 7.1).

Parents 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) [277]. 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 α = 0.79 (Table 7.1).

Environment: Parents of children in the study completed selected scales from the CLASS [277] 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 α = 0.60, access to equipment at home α = 0.70 and perceived access to physical activity opportunities in the local community α = 0.79 (Table 7.1).

7.2.4.3. Demographics and weight status

Children completed a questionnaire to obtain demographic information including sex, age, and suburb. The SEIFA index of relative socioeconomic disadvantage [295]

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 (weight[kg]/height[m]^2) and BMI z-scores were calculated using the 'LMS' method [300].

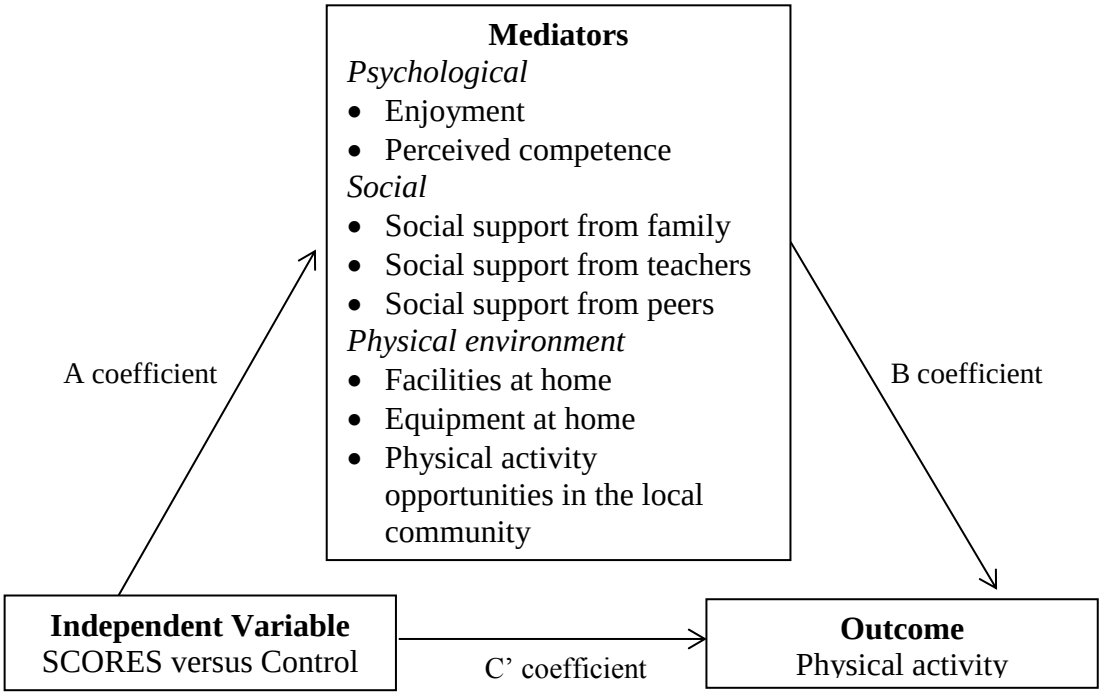

Figure 7.1 Mediation model showing the hypothesised mediators of the effect of the SCORES intervention on physical activity

7.2.5. 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 7.1). Stage 1, the action theory test, was calculated by regressing the hypothesised mediators onto treatment condition (A coefficient). Stage 2, the conceptual theory test, involved regressing physical activity onto treatment condition and the hypothesised 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 developed by Tofighi and MacKinnon [338] to test the significance of the product-of-coefficients (AB) by computing the confidence intervals for the mediated effect on the basis of the distribution-of-product method. This approach was selected as it is suggested for use with smaller samples and has additional power than traditional mediation tests, such as the Baron and Kenny test, which requires a much larger sample size [339]. 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.

7.3. Results

7.3.1. Overview

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. 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 [337].

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 5.0-20.5; $p = 0.008$).

7.3.2. Action theory test

Mediation results for total physical activity (MVPA minutes) as the outcome are presented in Table 7.2. The action theory test revealed a significant beneficial intervention effect for social support from teachers (A = 1.73, SE = 0.88, $p = 0.048$) and 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 other hypothesised mediators ($p > 0.05$).

7.3.3. Conceptual theory test

The results from the conceptual theory test showed a significant association between post-test perceived sport competence (B = 0.48, SE = 0.36, $p = 0.027$), perceived access to physical activity opportunities in the local community (B = 0.60, SE = 0.26, $p = 0.021$) and total MVPA levels, adjusting for baseline physical activity. There were no significant effects for any other hypothesised mediators for total MVPA ($p > 0.05$).

7.3.4. Significance test of mediated effect

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

7.4. 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., 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, perceived access to physical activity opportunities in the local community, acted as a causal mechanism explaining change in physical activity behaviour among children. Few studies have examined the mediating effects of physical activity opportunities in the local community on physical activity behaviours [81, 82], and to our knowledge this 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 [359], reinforcing the importance for community physical activity opportunities for both children and adolescents in promoting physical activity. Parent engagement strategies (i.e., 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., PCYC), 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 our 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 [81, 82]. 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 [83] or outdoor play frequency [84].

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 [83], 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 [354, 355]. 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 [336, 364, 365]. Although perceived competence did not mediate physical activity 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 [16, 87, 366]. 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 [82] and a school-based intervention which found perceived social support from teachers had no significant mediating effects on children's physical activity [85]. In contrast, a recent Australian study found that social support from teachers mediated physical activity behaviour change in children participating in the Fit-4-Fun intervention, suggesting further work in this area is warranted [83]. 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 [367, 368]. 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 [82-84]. 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 [83] and the possibility of this strategy causing increased awareness of peer social support or lack thereof, impacting on post-test data [369]. Further investigation into effective strategies to increase students' perceptions of peer social support in the primary school setting is needed.

Social support from family did not 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 behaviours through modelling, providing encouragement and facilitating environments conducive of physical activity [77, 370]. 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 [82, 83]. The limited finding in previous studies could be attributed to the challenge of engaging family members in physical activity programs [371]. 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 [337]. 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 hypothesised mediating mechanisms can prompt developers of future interventions to strengthen or add intervention components targeting these specific mediators. However, findings of limited mediation effects is also important for systematic progression of physical activity research as it will assist in understanding the relevance of hypothesised mediators and the effectiveness of the intervention strategies used. The limited mediation effects in the current study may be due to the SCORES intervention's inability to change the targeted constructs and/or inadequate dose, or measurement issues associated with the assessed mediators. As the constructs operationalized in the current study have been shown to be associated with physical activity behaviour in children [78] 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 behaviour in children, or are more appropriate mediators for different age groups such as adolescence.

7.4.1. Strengths and limitations

To our knowledge this is the first study to investigate the mediating effects of the physical environment (i.e., 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 behaviours 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 [26]. Children from low-income communities often demonstrate low levels of adherence to monitoring protocols and providing reliable accelerometer data [330]. Compliance levels in the current study appear to be consistent with other studies investigating population groups from low-income communities [330]. 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 behaviours as the criteria that was used in this study (i.e., three weekdays and one weekend) [33].

7.5. Conclusions

Findings from the current study add to the limited body of evidence examining mediators of behaviour change in physical activity interventions among children. This study has demonstrated the SCORES school-based physical activity intervention for children which resulted in significant group-by-time interaction effects for physical activity, was mediated by changes in the physical environment, specifically perceived access to physical activity opportunities in the local community. This provides evidence for recommending the inclusion of components to increase perceived access to physical activity opportunities in the local community as a mechanism of behaviour change, and thus, a strategy that should be included in interventions aimed at increasing children physical activity.

Table 7.1 Hypothesised mediators, intervention strategies and scale descriptions

Hypothesised mediators	Intervention strategies	Description of scale	Range No. of items	Source	α
Enjoyment	• *Professional learning workshops for teachers* - 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. Example item: "*When I am active...I enjoy it*" Scale: 1=Disagree a lot to 5=Agree a lot	1-5 9 items	Physical Activity Enjoyment Scale (PACES) [28]	0.79
Perceived sport competence	• *Professional learning workshops for teachers* - 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. Example item: "*Some kids wish they could be a lot better at sports BUT Other kids feel they are good enough at sports*" 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).	1-4 6 items	Perceived competence sub-scale from Harter's Self-Perception Profile (SPP) [29]	0.69

Social support from family	• *Newsletters* and *Parent evening* – Educate parents on the importance of and strategies for providing supportive environments for their child to be active. • *FMS homework* – 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. Example item: "*Encouraged you to do physical activities or play sports*" Scale: 1=Never to 5=Everyday	1-5 5 item	Scale developed for the Amherst Health and Activity Study [363]	0.85
		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. Example item: "*Father/male carer*" Scale: 1=Never to 6=Daily	1-6 8 item	Children's Leisure Activities Study Survey (CLASS) [277]	0.79
Social support from teachers	• *Professional learning workshops for teachers* - 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. Example item: "*During PE and school sport my teacher appears enthusiastic about the activity*" Scale: 1=Never to 5=Always	1-5 5 item	Existing scale developed for a previous study [276]	0.75

Social support from peers	• *Student leadership* - 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. Example item: "*Do your friends encourage you to do physical activities or play sports*" Scale: 1=Never to 5=Always	1-5 5 item	Scale developed for the Amherst Health and Activity Study [363]	0.65
Access to facilities at home	• *Newsletters* and *Parent evening* – 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. Example item: "*Sandpits/swings/play equipment*" Scale: 1=No to 2=Yes	1-2 11 item	CLASS [277]	0.60
Access to equipment at home		Parents of children in the study were asked to select how often their child accessed equipment at home. Example item: "*Bats/rackets*" Scale: 1=Don't have to 7=Daily	1-7 9 item	CLASS [23]	0.70

Perceived access to physical activity opportunities in the local community	• *Newsletters* and *Parent evening* – 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. • *Community links* – 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. Example item: "*There are few sporting venues within our local area*" Scale: 1=Strongly agree to 5=Strongly disagree	1-5 14 items	CLASS [23]	0.79

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

Table 7.2 Action theory test, conceptual theory test and significance of the mediated effect on total physical activity (MVPA minutes) at post-test (12-months)

Hypothesised mediators	n	Direct effect	Action theory test		Conceptual theory test		Significance of mediated effect		Proportion (%)
		C' (SE)	A (SE)	*p* value	B (SE)	*p* value	AB	95% CI	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%
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 behaviour accounting for effect of the mediator; A, unstandardised regression coefficient of treatment condition predicting change in hypothesised mediators; B, unstandardized regression coefficient of change in hypothesised mediators predicting change in physical activity behaviour; AB, product-of-coefficients estimate; SE, standard error; 95% CI, 95% confidence interval; *, significant ($p < 0.05$).

CHAPTER 8. DISCUSSION

As this thesis was presented as a series of publications, the findings for each of the research aims have been reported and comprehensively discussed in the preceding chapters. Thus, the purpose of this chapter is to synthesise these findings and present a series of evidence-based recommendations, and acknowledge the strengths and limitations of this body of work. The chapter concludes with the significance and future directions of SCORES. The discussion is structured in four main sections:

1. Previous FMS interventions in young people;
2. FMS competency and physical activity in children;
3. The impact of the SCORES intervention; and,
4. Understanding the mechanisms of physical activity behaviour change in the SCORES intervention.

The primary aim of this thesis was:

1. To evaluate the impact of the SCORES intervention on MVPA, cardiorespiratory fitness and FMS competency among children attending primary schools located in low-income communities (Chapter 5).

The secondary aims for this thesis were:

1. To systematically review the evidence of interventions designed to improve FMS competency in typically developing children and adolescents (Chapter 2).
2. To examine the association between FMS competency and objectively measured MVPA during time periods of the day that represent key physical activity opportunities (i.e., lunchtime, recess and after-school) among children attending primary schools located in low-income communities (Chapter 4).

3. To determine if changes in FMS competency and perceived competence mediated the effect of the SCORES intervention on MVPA and cardiorespiratory fitness among children attending primary schools located in low-income communities (Chapter 6).

4. To determine if changes in individual, social and physical environmental constructs mediated the effect of the SCORES intervention on MVPA among children attending primary schools located in low-income communities (Chapter 7).

8.1. Previous FMS interventions in young people

A key component of this thesis was focused on an investigation of the effectiveness of previous FMS interventions for young people. This component, which informed the development of the SCORES intervention and design of the cluster RCT, addressed *Secondary Aim 1*.

8.1.1. Review of FMS interventions in children and adolescents

Chapter 2 aim: To systematically review the evidence of interventions designed to improve FMS competency in typically developing children and adolescents (Secondary Aim 1).

Based on the available evidence, enhancing children's FMS appears to be an important strategy for increasing physical activity in young people. Moreover, FMS development is consistent with the physical literacy movement [372, 373] and is a central objective in PE curricula across the globe [374-376]. However, little is known regarding the effectiveness of interventions aimed to improve FMS competency in typically developing youth. The purpose of Chapter 2 was to perform a systematic review and meta-analysis of the effectiveness of interventions aimed to improve FMS competency in children and adolescents. All of the 19 interventions except one were conducted in primary school settings. Of note, all of the included studies found significant intervention effects for at least one FMS. The meta-

analyses revealed large effect sizes for overall gross motor and locomotor skill competency, and a medium effect size for object control skill competency.

The effect sizes observed in the review were large and greater than those reported in a prior meta-analysis of FMS interventions in children, mostly of preschool age [377]. Of note, the effect size for locomotor skills was greater than for object control skills. These findings are in contrast to the previous meta-analysis by Logan and colleagues [377], which reported no difference in effect size between locomotor and object-control skills. This inconsistency may be attributed to the differences in age and population groups, as the meta-analysis conducted by Logan and colleagues involved mainly younger children (i.e., preschool age) and children with developmental delays [377]. These findings suggest that object-control skills may be more challenging to develop than locomotor skills. This may be due to the increased skill component complexity and perceptual requirements of object-control skills, which may require more intense skill instruction and practice [49].

Of those studies in the review that compared enhanced PE to usual PE [327, 378-380] or free play [381], findings suggest the advantages of pedagogical approaches that provide opportunities for students to experience autonomy, developmentally appropriate learning activities and receive individualised feedback. This is noteworthy, as the control groups in these studies had the same time allocated in PE as the intervention group, indicating the value of modifying and engaging pedagogical approaches. Although research has established the benefit of direct instruction in PE [382, 383], student-centred approaches where students are provided with choice may increase intrinsic motivation [384], on-task behaviour, persistence, and FMS competency.

Other studies included in the review evaluated the effects of additional teacher training and/or time for PE lessons [68, 340, 385-391] compared to usual PE practice, and showed improved FMS outcomes. It was found that classroom teachers who received extensive professional learning and ongoing support could improve their students' FMS competency [391]. Moreover, greater FMS gains were achieved from larger doses of PE (five lessons per week), compared with usual dose (two lessons per week) [385, 387, 388]. However, considering the current issues identified

in primary school PE internationally, such as the challenges of a "crowded curriculum" [141, 392-394], it may not be possible or a viable strategy to allocate extra lesson time to PE.

Further, increasing the time allocated to PE may not occur in schools where there is considerable pressure to perform in academic subjects. Therefore, strategies to incorporate FMS learning beyond the school setting may have merit. The findings from this review suggests that promoting after-school activity [395-398] and including supplementary home-based FMS tasks [391, 395, 397] can enhance FMS development. Limited studies [387, 395, 397] reported engaging parents as an intervention strategy, which concurs with findings from a previous FMS review in younger children [399].

The findings from this review demonstrate that PE plays a key role in developing children's FMS, and PE specialists or generalist teachers who are provided with extensive and ongoing professional learning are needed to deliver such programs. Although the results from the review are positive, these results should be interpreted with some caution. Overall, a high risk of bias was identified, with less than one third of studies employing a RCT design. Most studies used a valid FMS measure; however no studies reported a power calculation for FMS outcomes. Further, there were a low number of studies and the school-based RCTs were conducted with small samples (less than 100).

8.1.2. Strengths and limitations

This review has a number of strengths including: i) adherence with the PRISMA Statement [400]; ii) a comprehensive search strategy across multiple databases with no date restrictions; iii) extensive study detail extracted; iv) a broad inclusion criteria; and, v) high agreement levels for risk of bias assessments. Despite the strengths of the review a number of limitations should be noted including: i) studies were required to be published in English; ii) inclusion of a generally modest number of heterogeneous studies; iii) inability to preclude publication bias; and iv) potential difficulty to compare studies due to the variety of FMS measures used.

8.2. FMS competency and physical activity in children

The second component of this thesis considered the association between FMS competency and children's physical activity during segmented time periods of the day. This component addressed *Secondary Aim 2*.

8.2.1. FMS competency and break-time and after-school physical activity in children

Chapter 4 aim: To examine the association between FMS competency and objectively measured MVPA during time periods of the day that represent key physical activity opportunities (i.e., lunchtime, recess and after-school) among children attending primary schools located in low-income communities (Secondary Aim 2).

A recent systematic review of the health benefits associated with FMS competency found strong evidence for a positive association between FMS competency and physical activity in children [51], however, little is known about the association between FMS competency and children's physical activity while at school (e.g., at recess and lunch) and immediately after school. Furthermore, few studies have examined these associations in children from low-income communities. Moreover, recent reviews of the effectiveness of physical activity interventions for children [104, 310] have reported modest effect sizes for physical activity. This may be in part due to an inadequate understanding of the key factors (i.e., FMS competency) that influence physical activity for a particular population (i.e., low socio-economic position) and in a specific context (i.e., school break-time or after-school).

The aim of Chapter 4 was to examine the associations between objectively measured MVPA and FMS during periods of the day that represent key physical activity opportunities for children. It was found that object-control skill competency, but not locomotor skill competency was significantly associated with children's MVPA during lunchtime and recess breaks at school. Furthermore, children who were more competent at object-control skills and locomotor skills were engaged in more MVPA in the after-school period. This appears to be the first study to investigate the

association between children's FMS competency and MVPA throughout key periods during a school week.

There are a number of possible explanations for these findings. For example, these associations may be indicative of the break-time environment. Equipment that is typically provided at break-times is for object-control sports (e.g., balls and bats). Further, popular break-time activities such as soccer and basketball are highly active but generally require higher levels of object-control skill competency [301]. Movement skill competency may affect the degree to which these activities and games are effectively performed, which could impact on activity levels [293]. Thus, higher skilled children may be more likely to be active than less skilled children, as they may gain greater enjoyment through participation due to their ability and likely greater opportunities for success. Moreover, it is possible that the more skilled children dominate these games and the areas available for activity during break-times, thus increasing their activity levels and reinforcing the divide between the low skilled and high skilled children. Although, the environment and policies (e.g., provision of equipment and activities) contribute to increased levels of physical activity among children during school break-times [302], it is possible that such approaches support the activity levels of more skilled children and fail to engage the least skilled individuals.

This study builds upon existing research for the after-school period by using an objective measure of physical activity and the comprehensive assessment of FMS using the TGMD-2 [63]. The results for this time period are consistent with previous research from cross-sectional studies involving primary school-aged children [307]. Existing evidence suggests that FMS competency is associated with after-school physical activity, with object-control (i.e., throwing) and locomotor (i.e., jumping) skills related to higher intensity after-school physical activity [307]. Combined, these results provide further evidence for the importance of developing FMS competence in primary school-aged children as a strategy for promoting physical activity during a key period of the day, especially when increasing time is spent engaging in sedentary activities (e.g., electronic entertainment) [305].

Children require quality instruction and practice opportunities to achieve a high level of FMS competency [49]. Providing quality FMS learning experiences during PE and school sport [102], may be as equally important as ensuring the break-time environment is conducive to a range of physically active choices, to optimise children's physical activity [302]. Further, quality FMS learning experiences and the break-time environment at school are particularly important for children living in low-income communities. Children from these communities typically have fewer opportunities to develop skills and engage in physical activities outside of school (i.e., the after-school period and on weekends) as cost of organised sport is a major barrier to physical activity participation in low-income areas [401].

8.2.2. Strengths and limitations

This study has a number of strengths including: i) the use of a comprehensive qualitative assessment of movement components of all major FMS; ii) an objective measure of physical activity; iii) statistical adjustment of potential confounders; and iv) a relatively large sample size. However, there are some limitations that should be noted including: i) accelerometers underestimate certain types of physical activity as they cannot be worn in the water and are insensitive to non-ambulatory activity such as cycling; ii) accelerometer wear time criteria are typically generated from whole-day data, therefore it is uncertain if the same criteria can be applied to discrete segments of the day [311]; and iii) due to the cross-sectional design of this study a cause-and-effect relationship between FMS and break-time and after-school physical activity cannot be inferred.

8.3. The impact of the SCORES intervention

This main component of this thesis was focused on the development of the primary school-based SCORES intervention and its evaluation via a cluster RCT. In addition to the study protocol for the RCT (Chapter 3), this component addressed the *Primary Aim* of the thesis.

8.3.1. Study outcomes for physical activity, cardiorespiratory fitness and FMS

Chapter 5 aim: To evaluate the impact of the SCORES intervention on MVPA, cardiorespiratory fitness and FMS competency among children attending primary schools located in low-income communities (Primary Aim).

SCORES was an innovative, multi-component intervention designed to target areas of considerable public health concern; specifically, inadequate physical activity levels [9, 10] and declining aerobic fitness levels of children [42] among a population group at risk of poor health (i.e., those from low-income communities) [13, 19, 402]. The intervention was focused on the development of FMS due to the significant and extensive health benefits associated with FMS competency [51]. The socio-ecological model [87] provided a framework for the SCORES intervention components, and within this framework, behaviour change strategies were selected and operationalised from self-determination theory [95, 96] and competence motivation theory [97, 351]. The intervention involved five key components: i) teacher professional learning, ii) student leadership, iii) policy and environment, iv) parental engagement, and v) community sporting links. The trial demonstrated significant beneficial effects for objectively measured MVPA, cardiorespiratory fitness and overall FMS competency.

After 12-months, the SCORES intervention resulted in a significant adjusted difference between intervention and control schools of 13 minutes of MVPA per day. This finding is comparable to the treatment effect observed (11 minutes per day) in the KISS program which involved the addition of daily PE lessons delivered by PE specialists [317] However, adding daily lessons delivered by specialists may not be feasible in many schools due to the pressures of a crowded curriculum and the cost of employing PE specialists [141]. Alternatively, the SCORES intervention was

able to achieve a similar 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 program dissemination and adoption. MVPA levels significantly declined among participants in the control group over the study period, however, activity levels were maintained in the intervention group. This finding is of considerable importance as it indicates the intervention was protective against the decline in physical activity that is typically observed in late childhood and early adolescence [349, 365].

Furthermore, a significant intervention effect was observed for after-school and weekend MVPA. This is a notable finding as the after-school period in particular, is considered a critical window of opportunity for physical activity, and often children have more choice of how they spend their time after-school and on weekends than when they are at school [288, 403]. The maintenance of MVPA during these time periods indicates the intervention may be effective in assisting children to self-regulate, resulting in the prevention of children choosing sedentary recreational activities during these time periods.

A significant intervention effect was also found for children's cardiorespiratory fitness. This is an important finding as cardiorespiratory fitness is an important marker of health and is more strongly associated with health outcomes than fatness in children [404]. Other high-quality school-based interventions have also reported improvements in cardiorespiratory fitness [106, 328, 329]. Interestingly, many of these trials have used PE specialists to deliver their programs, which have often included daily physical activity and/or fitness sessions. In contrast, SCORES achieved improvements in cardiorespiratory fitness with the generalist classroom teacher delivering the program and without additional sessions per week. It is plausible the SCORES intervention strategies that targeted maximising MVPA in PE lessons, as well as promoting physical activity of moderate-to-vigorous intensity within and beyond the school day over an extended period of time contributed to improvements in cardiorespiratory fitness.

A significant intervention effect was observed for overall FMS competency. The systematic review and meta-analysis of FMS interventions (Chapter 2) concluded

that enhanced PE programs that provide extensive and ongoing professional development for generalist teachers can improve FMS competency in children. Further, the benefit of student-centred approaches to FMS teaching [327, 397], in particular approaches that adopt a mastery climate, focus on success, optimal challenge and autonomy, were highlighted in the review. Based on these recommendations from this review, the SCORES intervention implemented professional learning for generalist teachers who were provided with ongoing support.

There were no significant treatment effects for MVPA, cardiorespiratory fitness or FMS at 6-months (mid-program). The lack of significant effects may be because the intervention was implemented in a three-phase approach whereby not all components were delivered in the first 6-months. In addition, although our process evaluation indicated that the intervention was delivered with a high level of fidelity, and teachers were satisfied with the intervention components, the lack of significant effects may be because it takes time for the intervention components to become adopted and implemented. For example, improvements in the quality of teaching in PE lessons (as demonstrated in the lesson observations and reported in the process evaluation results in Chapter 5), were only observed after the 6-month time-point of the intervention. Moreover, teachers reported in the process evaluation that it took some time to implement the student leadership component, which, combined, may have resulted in less physical activity opportunities in the first 6-months. Parent engagement and community link strategies which were implemented after the 6-month time-point were successful with good compliance and satisfaction from parents noted in the process evaluation. Compliance to school physical activity policies ranged, with school principals reporting that low compliance to some policies was due to implementation of these policies being more appropriate at the start of the school year rather than halfway through as delivered in the intervention, for example, policy 4 (annual reporting of students' FMS and fitness levels). Combined, these finding indicate that multi-component interventions delivered by classroom teachers may require a longer duration (i.e., at least 12-months) to produce changes in children's physical activity, cardiorespiratory and FMS competency.

8.4. Understanding the mechanisms of physical activity behaviour change in the SCORES intervention

The final component of this thesis focused on the investigation of mechanisms of physical activity behaviour change in the SCORES intervention. This component addressed *Secondary Aim 3* and *Secondary Aim 4.*

8.4.1. Mediators of the SCORES intervention

Chapter 6 aim: To determine if changes in FMS competency and perceived competence mediate the effect of the SCORES intervention on MVPA and cardiorespiratory fitness among children attending primary schools located in low-income communities (Secondary Aim 3).

Chapter 7 aim: To determine if changes in individual, social and physical environmental constructs mediate the effect of the SCORES intervention on MVPA among children attending primary schools located in low-income communities (Secondary Aim 4).

A mediation analysis was performed to explore the theoretical mechanisms of physical activity behaviour change [87, 95-97, 351] that guided the SCORES intervention. The constructs included: FMS competency; perceived competence; enjoyment; social support from family; social support from teachers; social support from peers; access to facilities at home; access to equipment at home; and perceived access to physical activity opportunities in the local community. Overall FMS competency was found to have a significant mediating effect on MVPA, and overall FMS and locomotor skills had a significant mediating effect on cardiorespiratory fitness. Of note, this was the first study to explore the mediating effects of FMS competency in a physical activity intervention in children. Although numerous cross-sectional and longitudinal studies have identified a positive association between FMS competency and physical activity and cardiorespiratory fitness in children [51], the causal pathways of influence had not been previously established in an experimental study. The SCORES intervention successfully targeted children's FMS competency, which contributed to improving physical activity levels. This suggests that improving overall FMS competency may act as a causal mechanism for MVPA

behaviour change and subsequent improvements in cardiorespiratory fitness among children. These findings support Stodden and colleague's conceptual model that posits the development of actual FMS competency as the primary underlying mechanism determining physical activity engagement [336].

Further, perceived access to physical activity opportunities in the local community was found to have a significant mediating effect on MVPA, indicating that this variable is a potential mechanism of physical activity behaviour change in children. Few studies have examined the mediating effects of access to physical activity opportunities in the local community on physical activity behaviours [81, 82]. These findings are similar to a previous study conducted in the adolescent population [359], reinforcing the importance of altering perceptions of and opportunities to access community physical activity for both age groups in promoting physical activity. Including intervention strategies 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.

No other theoretical constructs satisfied the criteria for mediation. This may be attributed to the SCORES intervention's inability to change the targeted constructs and/or measurement issues (e.g., ceiling effects or lack of sensitivity). As the constructs operationalised in the current study have been identified as correlates of physical activity behaviour in children [78], it is plausible to suggest that they have the potential to be relevant mediators if paired with effective intervention strategies. In addition, the challenges of measuring some psychological constructs in children may explain the null findings. Children may not possess the cognitive skills to accurately assess their physical abilities, and consequently, children often report exaggerated levels of psychological constructs [354, 355]. Further investigation of the identified potential mediators is needed to confirm if these are relevant mediators for physical activity behaviour in children, or are more appropriate mediators for different age groups such as adolescence. Overall, the lack of mediation studies conducted in the primary school setting and associated measurement issues has made it difficult to draw conclusions regarding the most effective mediators of physical activity behaviour change in children [81, 82].

8.4.2. Strengths and limitations

SCORES was an innovative, school-based physical activity intervention and one of the first to demonstrate significant intervention effects for objectively measured physical activity, cardiorespiratory fitness and FMS competency in children [106]. The SCORES intervention addressed many limitations of previous studies by: i) taking a multi-component, theoretically-driven, socio-ecological approach; ii) ensuring a high level of methodological quality (e.g., RCT and objective measure of physical activity); iii) evaluating intervention effects on physical activity beyond school-based to overall and out-of-school physical activity; iv) reporting the effect of the school-based physical activity intervention on FMS competency; v) addressing possible mediators of physical activity behaviour change and conducting mediation analysis of intervention effects; and vi) including family components in the intervention [106].

The SCORES intervention was evaluated using a cluster RCT and adhered to the Consolidation Standards of Reporting Trials (CONSORT) guidelines [316]. All primary and secondary outcomes were assessed using standardised protocols by trained research assistants who were blinded to treatment allocation at baseline (randomisation occurred after baseline assessments), and all outcomes were assessed using validated measures. Statistical analyses were adequately powered, followed the intention-to-treat principle, and were adjusted for relevant covariates and clustering of effects at the class level. Moreover, detailed process evaluation was conducted to assess fidelity and guide future intervention development and improvement.

Despite the study strengths, there are some limitations of the SCORES cluster RCT which should be noted. First, although the research team implemented 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%). Accelerometers are considered to be the ‘gold standard’ for assessing change in physical activity behaviour, however, compliance to monitoring protocols is often poor, particularly among children of low-SES [330]. Children who are socially disadvantaged or who live in disadvantaged areas are significantly less likely to provide reliable accelerometer

data [330]. Studies that measure only weekday or school-time (i.e., 9:00am-3:00pm Monday to Friday or break-time) physical activity often achieve higher rates of compliance [33, 85]. This was observed in the SCORES 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. Although, low accelerometer compliance was a study limitation, we did find significant treatment effects for cardiorespiratory fitness. Evidence suggests that to achieve improvements in cardiorespiratory fitness individuals need to regularly engage in MVPA [3], therefore, the high level of participant retention for cardiorespiratory fitness (84.7%) could be seen as a proxy for MVPA.

Second, an additional limitation is the self-reported measurement of the psychological, social and environment mediators. These measures may be subject to socially desirable response bias; and the potential low sensitivity to change of these measures. Third, although the 20-metre multistage fitness test is considered to have acceptable validity and reliability [44] and recommended by the Institute of Medicine [48] for assessing cardiorespiratory fitness in children and adolescents, this test is not a direct measure of VO_2 max. Finally, lack of a long-term follow-up is also a study limitation and there is a need to examine the sustained impact of the SCORES intervention (e.g., two years).

8.5. Recommendations

8.5.1. FMS interventions in young people

8.5.1.1. For practice

- Schools should ensure FMS lessons are delivered frequently in a pedagogically appropriate manner by PE specialists or highly trained classroom teachers (i.e., with extensive professional learning and ongoing support such as mentoring and / or lesson observations and feedback).

- Pedagogical approaches that enable the learner to experience autonomy (e.g., lessons involve elements of choice and opportunities for graded tasks), developmentally appropriate tasks (e.g., activities that accommodate for a variety of individual characteristics such as developmental status, previous movement experiences, fitness level, body size and age) and mastery (e.g., teaching skills in a non-competitive learning environment where all students have opportunities to achieve success), as well as receive individualised feedback (i.e., skill-specific) are recommended.

- Given that the primary school years are considered the optimal time to develop FMS and current issues with FMS learning contexts in primary schools, teacher pre-service training, teacher professional learning and resources should be prioritised so that children can receive quality FMS instruction and learning experiences.

- Given the limited time allocated to the PE curriculum in primary schools, strategies to involve parents in both school-based activities and to support FMS practice opportunities beyond school may be a valuable strategy to improve children's FMS competency.

- Further, education authorities may also need to consider the adoption of evidence-based FMS interventions / programs.

8.5.1.2. For research

- There is a need for more high quality trials that adhere to the CONSORT statement and Transparent Reporting of Evaluations with Nonrandomised Designs statements.

- Further, it is essential that researchers report their interventions in greater detail (e.g., dose, duration and fidelity of FMS activities, characteristics of facilitators and participants).

- Future studies should include follow-up assessments beyond the post-intervention time point to determine any sustained or long-term effects.

- Future research should focus on which pedagogical approaches and program components are associated with enhanced FMS competence and the optimal dose, duration, and intensity of interventions.

- Studies are required that investigate how evidence-based interventions can be translated and sustained without researcher support.

8.5.2. FMS and physical activity in children

8.5.2.1. For practice

- Schools and future programs designed to promote physical activity among children during school break-times and after-school, are encouraged to focus on improving children's FMS, as well as providing physical activity opportunities and environments for skill practice and application. For example: i) providing quality teaching of FMS during PE and sport; and ii) ensuring the lunchtime and recess environments are conducive to physically active choices (e.g., providing a variety of sporting equipment and games / activities that target both locomotor and object-control skills, and providing equal access to playground spaces for both girls and boys, and children of different age (i.e., different areas and / or times for different ages and sex).

- Schools need to consider the opportunities available to children to develop and practice FMS. It is recommended that teachers provide regular PE and use quality pedagogical strategies (e.g., mastery, autonomy, developmentally appropriate tasks, and individualised skill specific feedback) that provide all students with equal opportunities for successful movement skill acquisition, the development of self-esteem and optimal physical activity engagement, which can then be transferred outside of lessons into break-times and after-school.

8.5.2.2. For research

- Further research is needed to replicate the significant association between children's FMS competency and MVPA throughout key physical activity periods during the school day, as this appears to be the first study to investigate this association.

- It is important to consider the bidirectional relationship between FMS and physical activity [405], however there is limited research investigating the potential causal or bi-directional relationships between FMS competency and physical activity behaviour [405, 406]. Due to the cross-sectional design of the study the direction of this relationship could not be inferred. Future research should focus on investigating the mediating effects of FMS competency on physical activity during school break-times (i.e., recess and lunchtime) and after-school in children.

- Further research is needed to explore the impact of school break-time environments and policies on the physical activity levels of all students. It is important to determine the impact of such policies and environments on the physical activity levels of children with different skill levels and of different sex, to ensure that future policies and environments will not contribute to the skill and sex divide during school break-time (i.e., environments and policies increase physical

activity only among the more skilled children and boys, and fail to engage less skilled children and girls).

8.5.3. The impact of the SCORES intervention

8.5.3.1. For practice

- Schools should adopt a comprehensive and multi-level approach to physical activity promotion. Future primary school-based interventions / programs should be multi-component, and involve strategies that target behaviour change at the individual, interpersonal, organisational and community levels.

- Professional learning for classroom teachers that involves an initial intensive workshop plus ongoing support (i.e., lesson observations and feedback) is recommended to improve the quality of PE. Further, there is a need for online teacher professional learning components to enhance scalability.

- Pedagogical approaches which promote a mastery climate, such as the SAAFE (Supportive, Active, Autonomous, Fair and Enjoyable) principles, should be a key focus of the professional learning to support teachers to effectively develop children's FMS. Moreover, professional learning for teachers should include effective strategies for assessing children's FMS.

- The implementation of school physical activity policies is recommended. However, refinement of the timing of policy implementation to the beginning of the school year may be required in order to increase rates of policy adoption. Further, region / state wide implementation of the policies, as well as methods to increase school and teacher accountability (e.g., policies being governed by educational authorities) may also assist in policy adherence.

- Student leadership appears to be a feasible strategy to increase children's physical activity and FMS during school break-times.

Additional support (e.g., booster workshop for students and teachers) in the initial stages of implementation may be required.

- Creating school-community links appears to be a valuable strategy for physical activity promotion in children. School visits from a variety of local sporting organisations are recommended to increase students' awareness of, and participation in, sport and physical activity in their local community.

- It is recommended that incentives, such as teacher accreditation hours with local education authorities, be provided in order to increase teachers' motivation to complete professional learning and implement school physical activity strategies and policy. Further, regular physical activity is associated with increased academic performance and on-task behaviour in children [407, 408], thus reinforcing this association may prove as an additional motivator for schools and teachers.

8.5.3.2. For research

- Future school-based multi-component interventions delivered by classroom teachers may need to be at least 12-months in duration to produce changes in children's physical activity, cardiorespiratory and FMS competency outcomes.

- In addition, it is recommended that future school-based physical activity trials include follow-up assessments beyond the post-intervention time point to determine any sustained or long term effects.

- Further research is required to determine the most effective methods and implementation of student leadership strategies (e.g., content for student leadership workshop and tasks, teacher training to effectively support delivery of strategies, implementation structure and most appropriate age of the student leaders).

- Future school-based physical activity interventions should consider engaging parents using multiple strategies (i.e., newsletters, physical activity and FMS homework, and parent education evenings). However, more research is needed on effective methods to engage parents from low-SES communities in face-to-face education sessions.

- Future research is recommended to investigate cost-effective and sustainable partnerships between schools and community sporting organisations.

- Given the low accelerometer compliance rates, investigation of effective methods to increase adherence are needed. A suggestion for future studies would be to use an updated validated physical activity monitor which, for example, is worn on a participant's wrist, such as the GENEActiv monitors. Moreover, incentives used to increase adherence may need to be tailored to the specific population groups (e.g., food or supermarket vouchers for low socio-economic status communities) in order to increase compliance rates.

8.5.4. Understanding the mechanisms of physical activity behaviour change in the SCORES intervention

8.5.4.1. For practice

- The development of children's FMS competency should be a major focus / component of future interventions / programs and educational contexts to increase children's physical activity and cardiorespiratory fitness.

- A range of strategies should be implemented to support the development of children's FMS competency, including, teacher professional learning and ongoing support to improve the quality of PE, weekly FMS homework, student leadership tasks to promote FMS in the school, and implementation of school physical activity policies.

- Interventions / programs should focus on increasing perceived access to physical activity opportunities in the local community to promote children's engagement in physical activity. Including strategies in interventions / programs that educate and expose parents and children on where and how to access physical activity opportunities in the local community are recommended.

8.5.4.2. For research

- Future intervention design should include the development of FMS competency a mediator of physical activity behaviour change in children. However, as this study appears to be the first mediation analyses of FMS in a physical activity intervention, further research is needed to replicate these findings and whether this may be moderated by age and population group.

- Future interventions should include perceived access to physical activity opportunities in the local community as a mediator of physical activity behaviour change in children. This could be achieved through implementing effective parent and community engagement strategies; however, further research is needed to determine the most effective strategies, particularly in low-SES communities.

- Given the lack of mediation studies in children and measurement issues, more investigation of physical environmental, psychological, and social mediators in successful high quality physical activity interventions are needed.

8.6. Significance and future directions of the SCORES intervention

8.6.1. Significance of the SCORES intervention

The importance of our study findings were noted by the Editor-in-Chief of Medicine & Science in Sports & Exercise in his April 2015 News and Views Commentary:

> *"From this month's issue of MSSE, I would like to direct your attention to two articles on the role of moderate-to-vigorous physical activity (MVPA) in health. Cohen et al. evaluated one such program to encourage increased physical activity in children. These investigators studied impacts of the Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES) intervention in 25 classes from eight primary schools located in low income communities in Australia. After 12-months, SCORES resulted in significant improvements in MVPA, cardiorespiratory fitness and fundamental movement skills. Findings from this study suggest that primary schools can achieve these results without allocating additional curriculum time to physical education. This study provides further support for the importance of implementing appropriate, comprehensive school physical activity"* (Bruce Gladden, Editor-in-Chief Medicine & Science in Sports & Exercise, News and Views Commentary April 2015).

The SCORES intervention has the potential to be adopted in schools without adding to the current issues identified in primary school settings, such as the major limitations of a "crowded curriculum", poor teacher expertise and lack of evidence-based programs [23-26]. For example, the intervention: i) does not require additional time allocation to PE and school sport; ii) can be conducted by classroom teachers (i.e., PE specialists do not need to be employed); and iii) components are conducted outside of curriculum time (i.e., student leadership, parental engagement and community links).

The capacity of the SCORES intervention to be translated into the real-world school setting has been demonstrated by the resources developed for the SCORES intervention currently being delivered to schools as part of the Healthy Children's Initiative, which is a project combining Hunter New England Population Health and

the NSW Department of Education and Communities. The Healthy Children's Initiative is focused on improving the nutrition and physical activity levels of school children across the Hunter New England area in approximately 400 primary schools. To date, 63 primary schools and 635 teachers have participated in the SCORES professional learning workshop. Teachers have reported the workshop: i) was enjoyable (mean 4.7 / 5); ii) increased their understanding of the importance of FMS (mean 4.5 / 5); iii) improved their knowledge of how to plan effective PE lessons focussing on FMS (mean 4.4 / 5); iv) improved their understanding of how to implement FMS lessons (mean 4.4 / 5); v) provided them with useful lesson plan ideas (mean 4.6 / 5); and vi) provided them with useful resources (mean 4.7 / 5).

8.6.2. Future directions of the SCORES intervention

An abundance of school-based physical activity intervention efficacy trials have been conducted in recent years [107], however these efforts have had limited impact on school policy and practice [409]. Further, there is a considerable gap between successful interventions and dissemination in real world contexts [410, 411]. The next phase for the SCORES intervention is to explore the generalisability of the results for the broader population in a dissemination trial.

Guided by the research and practice recommendations arising from the SCORES cluster RCT, our research team, in collaboration with Australian Catholic University, Deakin University and the New South Wales (NSW) Department of Education and Communities, was awarded a National Health and Medical Research Council (NHMRC) Partnership Grant ($1.3 million) for the SCORES dissemination project. The SCORES dissemination project is guided by the RE-AIM framework [412]. This framework is powerful as it allows for program evaluation in real-life contexts and provides evidence concerning the capacity of the intervention to be translated at a population level [412]. In addition, a large portion of our professional learning training will now be delivered online as web-based delivery can support scaling-up and sustainability. Recent evidence suggests that web-based professional learning for teachers can be as effective as face-to-face training [413]. In alignment with the RE-AIM framework, we will evaluate the Reach, Effectiveness, Adoption, Implementation and Maintenance of SCORES when disseminated in 200 NSW

primary schools. Primary outcome (cardiorespiratory fitness) and secondary outcomes (objectively measured physical activity, FMS competency, and academic performance) will be assessed at 12-months (immediate post intervention) and 24-months (long-term follow-up).

The future, long term aim is for SCORES to be scalable and effective, and become embedded as part of routine best-practice physical activity promotion in primary schools throughout NSW and Australia.

8.7. Concluding remarks

Schools provide an ideal setting for the promotion of physical activity. The SCORES school-based intervention was theoretically-driven and involved strategies that targeted behaviour change at the individual, interpersonal, organisational and community levels. The findings presented demonstrate the potential for comprehensive, multi-component school-based interventions to promote physical activity, cardiorespiratory fitness and FMS competency in children attending primary schools in low-income communities. Further, the findings provide evidence for the inclusion of FMS development as a mechanism of behaviour change and, thus, a strategy that should be included in interventions aimed at increasing children's physical activity and cardiorespiratory fitness. The future dissemination of SCORES will provide evidence for the generalisability of the current findings, and further inform future school policy and practice in physical activity promotion.

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Appendix 1. Statements of contribution

Appendix 2. University of Newcastle Human Research Ethics Committee approval letter

HUMAN RESEARCH ETHICS COMMITTEE

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

Notification of Expedited Approval

To Chief Investigator or Project Supervisor:	**Associate Professor David Lubans**
Cc Co-investigators / Research Students:	**Professor Philip Morgan** **Professor Ronald Plotnikoff** **Professor Robin Callister** **Mrs Deborah Dewar**
Re Protocol:	**Evaluation of a school-based physical activity program in disadvantaged primary schools: The Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES) Study.**
Date:	**07-Sep-2011**
Reference No:	**H-2011-0214**
Date of Initial Approval:	**06-Sep-2011**

Thank you for your **Response to Conditional Approval (minor amendments)** submission to the Human Research Ethics Committee (HREC) seeking approval in relation to the above protocol.

Your submission was considered under **Expedited** review by the Ethics Administrator.

I am pleased to advise that the decision on your submission is **Approved** effective **06-Sep-2011**.

In approving this protocol, the Human Research Ethics Committee (HREC) is of the opinion that the project complies with the provisions contained in the National Statement on Ethical Conduct in Human Research, 2007, and the requirements within this University relating to human research.

Approval will remain valid subject to the submission, and satisfactory assessment, of annual progress reports. *If the approval of an External HREC has been "noted" the approval period is as determined by that HREC.*

The full Committee will be asked to ratify this decision at its next scheduled meeting. A formal *Certificate of Approval* will be available upon request. Your approval number is **H-2011-0214**.

If the research requires the use of an Information Statement, ensure this number is inserted at the relevant point in the Complaints paragraph prior to distribution to potential participants You may then proceed with the research.

Conditions of Approval

This approval has been granted subject to you complying with the requirements for *Monitoring of Progress*, *Reporting of Adverse Events*, and *Variations to the Approved Protocol* as detailed below.

PLEASE NOTE:
In the case where the HREC has "noted" the approval of an External HREC, progress reports and reports of adverse events are to be submitted to the External HREC only. In the case of Variations to the approved protocol, or a Renewal of approval, you will apply to the External HREC for approval in the first instance

and then Register that approval with the University's HREC.

- ***Monitoring of Progress***

Other than above, the University is obliged to monitor the progress of research projects involving human participants to ensure that they are conducted according to the protocol as approved by the HREC. A progress report is required on an annual basis. Continuation of your HREC approval for this project is conditional upon receipt, and satisfactory assessment, of annual progress reports. You will be advised when a report is due.

- ***Reporting of Adverse Events***

1. It is the responsibility of the person **first named on this Approval Advice** to report adverse events.
2. Adverse events, however minor, must be recorded by the investigator as observed by the investigator or as volunteered by a participant in the research. Full details are to be documented, whether or not the investigator, or his/her deputies, consider the event to be related to the research substance or procedure.
3. Serious or unforeseen adverse events that occur during the research or within six (6) months of completion of the research, must be reported by the person first named on the Approval Advice to the (HREC) by way of the Adverse Event Report form within 72 hours of the occurrence of the event or the investigator receiving advice of the event.
4. Serious adverse events are defined as:
    - Causing death, life threatening or serious disability.
    - Causing or prolonging hospitalisation.
    - Overdoses, cancers, congenital abnormalities, tissue damage, whether or not they are judged to be caused by the investigational agent or procedure.
    - Causing psycho-social and/or financial harm. This covers everything from perceived invasion of privacy, breach of confidentiality, or the diminution of social reputation, to the creation of psychological fears and trauma.
    - Any other event which might affect the continued ethical acceptability of the project.

5. Reports of adverse events must include:
    - Participant's study identification number;
    - date of birth;
    - date of entry into the study;
    - treatment arm (if applicable);
    - date of event;
    - details of event;
    - the investigator's opinion as to whether the event is related to the research procedures; and
    - action taken in response to the event.

6. Adverse events which do not fall within the definition of serious or unexpected, including those reported from other sites involved in the research, are to be reported in detail at the time of the annual progress report to the HREC.

- ***Variations to approved protocol***

If you wish to change, or deviate from, the approved protocol, you will need to submit an *Application for Variation to Approved Human Research.* Variations may include, but are not limited to, changes or additions to investigators, study design, study population, number of participants, methods of recruitment, or participant information/consent documentation. **Variations must be approved by the (HREC) before they are implemented** except when Registering an approval of a variation from an external HREC which has been designated the lead HREC, in which case you may proceed as soon as you receive an acknowledgement of your Registration.

Linkage of ethics approval to a new Grant

HREC approvals cannot be assigned to a new grant or award (ie those that were not identified on the application for ethics approval) without confirmation of the approval from the Human Research Ethics Officer on behalf of the HREC.

Best wishes for a successful project.

Professor Alison Ferguson
Chair, Human Research Ethics Committee

For communications and enquiries:
Human Research Ethics Administration

Research Services
Research Integrity Unit
HA148, Hunter Building
The University of Newcastle
Callaghan NSW 2308
T +61 2 492 18999
F +61 2 492 17164
Human-Ethics@newcastle.edu.au

Linked University of Newcastle administered funding:

Funding body	Funding project title	First named investigator	Grant Ref

Appendix 3. NSW Department of Education and Communities approval letter

NSW GOVERNMENT Education & Communities

A/Prof David Lubans
School of Education
University of Newcastle
CALLAGHAN NSW 2308

DOC 11/225645

Dear A/Prof Lubans SERAP Number **2011200**

I refer to your application to conduct a research project in New South Wales government schools entitled *Evaluation of a school-based physical activity program in disadvantaged primary schools: The Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES) study*. I am pleased to inform you that your application has been approved. You may now contact the Principals of the nominated schools to seek their participation. **You should include a copy of this letter with the documents you send to schools.**

This approval will remain valid until 06/09/2012.

The following researchers or research assistants have fulfilled the Working with Children screening requirements to interact with or observe children for the purposes of this research for the period indicated:

Name	**Approval expires**
Philip James Morgan	20/09/2012
Kristen Emilie Weaver	20/09/2012
David Revalds Lubans	20/09/2012
Deb Louise Dewar	20/09/2012
Sarah Anne Costigan	29/08/2011

I draw your attention to the following requirements for all researchers in New South Wales government schools:

- School Principals have the right to withdraw the school from the study at any time. The approval of the Principal for the specific method of gathering information for the school must also be sought.
- The privacy of the school and the students is to be protected.
- The participation of teachers and students must be voluntary and must be at the school's convenience.
- Any proposal to publish the outcomes of the study should be discussed with the Research Approvals Officer before publication proceeds.

When your study is completed please forward your report marked to Manager, Schooling Research, Department of Education and Training, Locked Bag 53, Darlinghurst, NSW 2010
Yours sincerely

Bill Tomlin
R/Senior Manager
Student Engagement and Program Evaluation
5 October 2011

Student Engagement and Program Evaluation Bureau NSW Department of Education and Communities
Level 3, 1 Oxford Street, Darlinghurst NSW 2010 – Locked Bag 53, Darlinghurst NSW 1300 Telephone: 02 9244 5619– Fax: 02 9266 8233 – Email: serap@det.nsw.edu.au

Appendix 4. Principal information statement and consent form

A/Prof David Lubans
School of Education
Faculty of Education and Arts
University of Newcastle
Callaghan NSW 2308
Phone: + 61 (0)2 4921 2049
Fax: +61 (0)2 4921 7407
Email: David.Lubans@newcastle.edu.au

Research Project: Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES)

PRINCIPAL INFORMATION STATEMENT

Dear Principal,

Your school is invited to participate in the research project identified above which is being conducted by A/Prof David Lubans, Prof Philip Morgan, Prof Ron Plotnikoff and Prof Robin Callister and Mrs Deborah Dewar from the University of Newcastle. This research is funded through the Hunter Medical Research Institute.

Why is this research being done?

Low levels of physical activity and high levels of overweight and obesity have contributed to a number of health problems for Australian children. Competency in a range of movement skills (e.g. kicking, running, throwing) is the foundation for an active lifestyle. The aim of this study is to evaluate the impact of a school-based movement skills program on the physical activity behaviour and mental health of primary school children.

Who can participate in this research?

Students in grades 3 and 4 at your school and their teachers are eligible to participate in this study. We aim to recruit 60 students from each of the schools. Parents will be asked to complete a questionnaire about their children's physical activity. They will also be invited to attend an information evening and participate in school sport sessions.

What choice do you have?

Participation in this research is entirely your choice and only schools where principals have given their explicit consent will be included in the study. If you do agree to your school's participation, you may withdraw from the study at any time without giving a reason. A decision not to participate or discontinuation of involvement in the study will not jeopardise your relationship with the University of Newcastle. Similarly, students in your school will be included in the study only after a consent form has been signed by their parents/guardians. If they initially agree to participate, they can choose to withdraw from the study at any time without giving a reason.

What is involved in this study?

Schools who agree to participate will be ***randomly allocated*** to either a study program recipient group or a wait list control group. Schools allocated to the wait list control will not receive the study program during the study period. However, the program will be delivered in these schools at the completion of the study.

The program will run for two full school terms (terms 2 and 3, 2012) and will aim to improve movement skills and physical activity levels among students. Students in **BOTH** groups will complete evaluation measures on three occasions during the study period (baseline, 6- and 12-months). The program components and evaluation measures are listed below in Table 1.

Table 1: Program components and evaluation strategies

Program components ***(Wait list control schools will receive the program components in 2013).***	***Evaluation of program*** ***(Measures will be completed by all participants in BOTH program recipient schools and wait-list control schools).***
The program involves the following five (5) components: i) *Professional development for teachers* (1 x full day for school champions[2], 1 x half day for all teachers at intervention schools) – The research team will deliver professional development workshops for teachers. Workshops will focus on effective teaching methods for the development of FMS, strategies for assessing FMS, increasing ALT and promoting physical activity in PE and school sport. a. *School champion workshop:* will be held at the university. b. *Whole-school workshops:* will be delivered in the study schools during one of their scheduled professional development days. ii) *Student leadership* (1 x 2 hours) – Students will be provided with an opportunity to achieve SCORES leadership accreditation. This will provide students with formal acknowledgment (i.e. certificates) and rewards (i.e. water bottles, stickers and balls) for their participation. SCORES leaders will be encouraged to help organise and deliver lunch and recess activities at school. Workshops will be delivered at the study schools during PE/school sport by the research team. iii) *Community links* (6 x visits) – Community organisations (e.g. local football clubs) will be invited to the visit the study schools during PE/school sport. This will help to promote community sporting links. iv) *Policy and environment* (on-going) – 2 strategies will be used: a. *Policy review and recommendations:* The research team will conduct a review of physical activity policy in the schools. The research team will work with Principals to revise policy to support the physical activity promotion. b. *Equipment and resources:* Each school will be provided with physical activity equipment (e.g. bats, balls etc) and resources (e.g. activity cards) to support the implementation of the intervention based on their individual school needs (approx. $1,000). *v) Parental engagement* – 3 strategies will be used to involve parents: a. *Newsletters* - Parents of study participants will be provided with newsletters to educate and encourage them to support their children's physical activity behaviors. Newsletters will also provide updates and feedback on the project. b. *FMS Homework* – Students will be encouraged to complete practical homework tasks focused on FMS development with their parents/guardians. c. *Parent evening* – Parents will be invited to attend an information session on how to promote and increase physical activity and FMS in the home setting.	*Students* The following measures will be taken 3 times (baseline, 6-months and 12-months): • *Cardio-respiratory fitness:* using the 20m shuttle test. • *Physical activity:* an accelerometer[1] will be worn for 7 days to determine changes in physical activity. • *Fundamental movement skill:* using a standard test (TGMD II) including six locomotor and six object control skills which will be video-taped for assessment. The following measures will be taken 2 times (baseline and 12-months): • *Height:* using a stadiometer. • *Weight:* using a calibrated scale. • *Questionnaires*: assessing self-esteem, resilience, and physical activity behaviours. *Physical education (PE) / sport lesson observations:* • The research team will observe PE/sport lessons and use SOFIT and the SCORES lesson observation form to assess the effectiveness of lessons. *Teachers* • *Questionnaire:* regarding physical activity opportunities in the school environment. *Parents* • *Questionnaires:* regarding children's physical activity and activity-related parenting practices.

Note: FMS = Fundamental Movement Skills; PE = physical education; ALT = active learning time; SCORES = Supporting Children's Outcomes using Rewards, Exercise and Skills; SOFIT = System for Observing Fitness Instruction Time. [1] An accelerometer is a small device that clips to the belt or waistband and is used to measure physical activity. [2] School champions are the classroom teachers of students in the intervention schools

Who will be responsible for delivering and administering the program?

The success of the program is dependent upon the participation of teachers at the study schools. While teachers will not be paid for delivering the intervention, payment for release time will be provided to assist with time spent completing tasks that are directly related to the evaluation component of the program (i.e. collecting and administering consent letters as well as scheduling and supervising assessment sessions). An outline of program administration and delivery responsibilities is provided below:

- A *professional development workshop for school champion*[2] will be delivered by members of the research team at the University of Newcastle.
- *A professional development workshop for all teachers at the study schools* will be delivered by the research team in the school during one of their scheduled professional development days.
- The *student leadership workshop* will be delivered by members of the research team, but a member of the school's staff will need to be present to supervise students.
- *Community organisations* (e.g. local football clubs) will be invited to the visit the study schools during PE/school sport to help promote community sporting links. A member of the school's staff will need to be present for all of these 6 visits to supervise students.
- The *recess and lunchtime activity sessions* will be delivered by SCORES leadership accredited students, but a member of the school's staff will need to be present to supervise students. We will encourage staff and parents to participate in the sessions.
- Assessments will be conducted by members of the research team but a member of the school's staff will need to be present to supervise students at all assessments.

Study timetable

Date	**Event**
October-November (2011)	Recruitment of schools and participants
February-March (2012)	Collection of baseline data
April-May (2012)	Phase 1 of intervention
August-September (2012)	Phase 2 of the intervention
September-November (2012)	Collection of 6-month data
Feb (2013)- March (2013)	Collection of 12-month data

What are the risks and benefits of participating?

The evaluation measures will be carried out by trained research assistants. The enhanced school sport sessions will be developed by the research team and delivered by a suitable member of the school's teaching staff. Based on previous studies, students will have no greater chance of injury by participating in these programs in comparison to other sports and physical activities. The program will provide students with an opportunity to increase their knowledge and skills and improve attitudes toward physical activity and nutrition. Students will also benefit from participation in a variety of enjoyable exercise activities. Staff involved in running these sessions will also personally benefit through acquired knowledge, skills and fitness. These sessions will also provide opportunities for professional development through the provision of resources and programs to assist with session delivery.

How will the information collected be used?

The data collected from this study will be used for journal publications and conference presentations and to inform future practice for the design of valuable, evidence-based school sport programs.

How will privacy be protected?

Any personal information provided by students and parents will be confidential to the researchers. The results of the study will be published in general terms and will not allow the identification of individual students or schools. Once the data has been collected, de-identified using participant codes and entered into an electronic data file, questionnaires and other data collection sheets will be destroyed. The electronic data files will be retained for at least 5 years but no individual will be identifiable in the data files or published reports.

What do you need to do to participate?

If you are willing for your school to participate in this study, could you please complete the accompanying Consent Form and return it to the researchers in the reply paid envelope provided. Upon receipt of your consent, a member of the research team will contact you to organise a time to visit the school and provide students with information about the study. If you would like to organise a different route for the dissemination of the Information Sheet and Consent Form to students, please let A/Prof Lubans know. All students wanting to participate in this study will be required to return a Consent Form, which his/her parents/guardians have signed before the study starts.

Further information

Following the completion of the study, the school will be sent a report describing the findings of the study. Results will also be sent via post to study participants and their parents. Individual results will not be given to students.

If you would like further information please do not hesitate to contact A/Prof David Lubans. Thank you for considering this invitation.

A/Prof David Lubans	Prof Philip Morgan	Prof Robin Callister
Faculty of Education & Arts School of Education University of Newcastle Phone: (02) 4921 2049 David.Lubans@newcastle.edu.au	Faculty of Education & Arts School of Education University of Newcastle Phone: (02) 4921 7265 Philip.Morgan@newcastle.edu.au	Faculty of Health Biomedical Sciences & Pharmacy University of Newcastle Phone: (02) 4921 5650 Robin.Callister@newcastle.edu.au

Prof Ron Plotnikoff	Mrs Deborah Dewar
Faculty of Education & Arts School of Education University of Newcastle Phone: (02) 4985 4465 Ron.Plotnikoff@newcastle.edu.au	Faculty of Education & Arts School of Education University of Newcastle Phone: (02) 49 854255 Deborah.Dewar@newcastle.edu.au

This project has been approved by the University's and NSW DET Ethics committees, Approval numbers H-2011-0214 SERAP 2011200. Should you have concerns about your rights as a participant in this research, or you have a complaint about the manner in which the research is conducted, it may be given to the researcher, or, if an independent person is preferred, to the Human Research Ethics Officer, Research Office,

A/Prof David Lubans
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Email:

Research Project: Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES)

PRINCIPAL CONSENT FORM

Chief Investigators: A/Prof David Lubans, Prof Philip Morgan, Prof Ron Plotnikoff,

Prof Robin Callister & Ms Deborah Dewar

I have been given information about the project identified above. I understand that if I consent to my school's involvement in this project, consenting students will participate in the study entitled: Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES) and my school will be randomly allocated to one of two interventions:

i)The study program recipient group: where student participants will receive a 6-month physical activity program.

ii)The wait-list control group: where student participants will receive the physical activity program at the end of the study period.

I understand that consenting students will also complete the following program evaluation measures: physical activity and movement skills proficiency, height and weight, cardio-respiratory fitness, self-esteem, resilience, and physical activity behaviours. I also understand that physical education / sport lessons will be observed by members of the research team.

I have had an opportunity to ask A/Prof Lubans questions about the research. I understand that my school's participation in this research is voluntary and that my school and my students are free to withdraw from the research project at any time. My refusal to participate or withdrawal of consent will not affect my relationship with the University of Newcastle.

By signing below I am indicating my consent for my school to participate in this research project conducted by A/Prof David Lubans. I am also consenting for the provision of time and space for (1) members of the research team to deliver information to potential student participants at a recruitment presentation; (2) delivery of the study's intervention components during timetabled PE and school sport and weekly lunch periods which will be supervised by interested school staff (3) members of the research team to collect evaluation measures from student participants and to observe teachers PE lessons and complete the teacher questionnaire three times during the study period.

Name of school: _____

Principal's name: _____

Signature: _____ **Date:** _____

PLEASE FAX OR EMAIL COMPLETED SHEET BACK ASAP TO DAVID LUBANS- FAX. No. 4921 2084 OR David.Lubans@newcastle.edu.au

This project has been approved by the University's and NSW DET Ethics committees, Approval numbers H-2011-0214 SERAP 2011200. Should you have concerns about your rights as a participant in this research, or you have a complaint about the manner in which the research is conducted, it may be given to the researcher, or, if an independent person is preferred, to the Human Research Ethics Officer, Research Office,

Appendix 5. Teacher information statement and consent form

A/Prof David Lubans
School of Education
Faculty of Education and Arts
University of Newcastle
Callaghan NSW 2308
Phone: + 61 (0)2 4921 2049
Fax: +61 (0)2 4921 7407
Email: David.Lubans@newcastle.edu.au

Research Project: Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES)

TEACHER INFORMATION STATEMENT

Dear Teacher,

Your school is invited to participate in the research project identified above which is being conducted by A/Prof David Lubans, Prof Philip Morgan, Prof Ron Plotnikoff, Prof Robin Callister and Mrs Deborah Dewar from the University of Newcastle. This research is funded through the Hunter Medical Research Institute.

Why is this research being done?

Low levels of physical activity and high levels of overweight and obesity have contributed to a number of health problems for Australian children. Competency in a range of fundamental movement skills is the foundation for an active lifestyle. The aim of this study is to evaluate the impact of a school-based Physical Education and fundamental movement skills proficiency program on the physical activity behaviour of primary school children.

Who can participate in this research?

Teachers with participating students in grades 3 and 4 at your school are eligible to participate in this study. We aim to recruit 60 students from each of the recruited schools.

What choice do participants have?

The school principal has agreed to your school being involved in the study. However, participation in this study is entirely the student's and their parent's choice. Students who agree to participate can choose to withdraw from the study at any time and will be free to discontinue participation in the assessments at any time. A decision not to participate or discontinuation of involvement in the study will not jeopardise student's relationship with the University of Newcastle or the school.

What is involved in this study?

Schools who agree to participate will be ***randomly allocated*** to either a study program recipient group or a wait list control group. Schools allocated to the wait list control will not receive the study program during the study period. However, program materials will be made available to these schools following completion of the study.

Consenting students from schools receiving the study program will participate in a physical activity and fundamental movement skills proficiency program, which will be based at school. The program will run for two full school terms (terms 2 and 3, 2012). Students in **BOTH** groups will complete evaluation measures on three occasions during the study period (baseline, 6- and 12-months). The program components and evaluation measures are listed below in Table 1.

Table 1: Program components and evaluation strategies

Program components ***(Students from wait-list control schools will not receive program materials until study completion)***	***Evaluation of program*** ***(Measures taken from study participants in BOTH program recipient schools and wait-list control schools).***
The program involves the following five (5) components: i) *Professional development for teachers* (1 x full day for school champions[2], 1 x half day for all teachers at intervention schools) – The research team will deliver professional development workshops for teachers. Workshops will focus on effective teaching methods for the development of FMS, strategies for assessing FMS, increasing ALT and promoting physical activity in PE and school sport. a. *School champion workshop:* will be held at the university. b. *Whole-school workshops:* will be delivered in the study schools during one of their scheduled professional development days. ii) *Student leadership* (1 x 2 hours) – Students will be provided with an opportunity to achieve SCORES leadership accreditation. This will provide students with formal acknowledgment (i.e. certificates) and rewards (i.e. water bottles, stickers and balls) for their participation. SCORES leaders will be encouraged to help organise and deliver lunch and recess activities at school. Workshops will be delivered at the study schools during PE/school sport by the research team. iii) *Community links* (6 x visits) – Community organisations (e.g. local football clubs) will be invited to the visit the study schools during PE/school sport. This will help to promote community sporting links. iv) *Policy and environment* (on-going) – 2 strategies will be used: a. *Policy review and recommendations:* The research team will conduct a review of physical activity policy in the schools. The research team will work with Principals to revise policy to support the physical activity promotion. b. *Equipment and resources:* Each school will be provided with physical activity equipment (e.g. bats, balls etc) and resources (e.g. activity cards) to support the implementation of the intervention based on their individual school needs (approx. $1,000). *v) Parental engagement* – 3 strategies will be used to involve parents: a. *Newsletters* - Parents of study participants will be provided with newsletters to educate and encourage them to support their children's physical activity behaviors. Newsletters will also provide updates and feedback on the project. b. *FMS Homework* – Students will be encouraged to complete practical homework tasks focused on FMS development with their parents/guardians. c*. Parent evening* – Parents will be invited to attend an information session on how to promote and increase physical activity and FMS in the home setting.	*Students* The following measures will be taken 3 times (baseline, 6-months and 12-months): • *Cardio-respiratory fitness:* using the 20m shuttle test. • *Physical activity:* an accelerometer[1] will be worn for 7 days to determine changes in physical activity. • *Fundamental movement skill:* using a standard test (TGMD II) including six locomotor and six object control skills which will be video-taped for assessment. The following measures will be taken 2 times (baseline and 12-months): • *Height:* using a stadiometer. • *Weight:* using a calibrated scale. • *Questionnaires*: assessing self-esteem, resilience, and physical activity behaviours. *Physical education / sport lesson observations:* • The research team will observe PE/sport lessons and use SOFIT and the SCORES lesson observation form to assess the effectiveness of lessons. *Teachers* • *Questionnaire:* regarding physical activity opportunities in the school environment. *Parents* • *Questionnaires:* regarding children's physical activity and activity-related parenting practices.

Note: FMS = Fundamental Movement Skills; PE = physical education; ALT = active learning time; SCORES = Supporting Children's Outcomes using Rewards, Exercise and Skills; SOFIT = System for Observing Fitness Instruction Time. [1] An accelerometer is a small device that clips to the belt or waistband and is used to measure physical activity. [2] School champions are the classroom teachers of students in the intervention schools.

Who will be responsible for delivering and administering the program?

The success of the program is dependent upon the participation of teachers at the study schools. While teachers will not be paid for delivering the intervention, payment for release time will be provided to assist with time spent completing tasks that are directly related to the evaluation component of the program (i.e. collecting and administering consent letters as well as scheduling and supervising assessment sessions). An outline of program administration and delivery responsibilities is provided below:

- A *professional development workshop for school champions*[3] will be delivered by members of the research team at the University of Newcastle.
- *A professional development workshop for all teachers at the study schools* will be delivered by the research team in the school during one of their scheduled professional development days.
- The *student leadership workshop* will be delivered by members of the research team, but a member of the school's staff will need to be present to supervise students.
- *Community organisations* (e.g. local football clubs) will be invited to the visit the study schools during PE/school sport to help promote community sporting links. A member of the school's staff will need to be present for all of these 6 visits to supervise students.
- The *recess and lunchtime activity sessions* will be delivered by SCORES leadership accredited students, but a member of the school's staff will need to be present to supervise students. We will encourage staff and parents to participate in the sessions.
- Assessments will be conducted by members of the research team but a member of the school's staff will need to be present to supervise students at all assessments.

Study timetable

Date	Event
October-November (2011)	Recruitment of schools and participants
February-March (2012)	Collection of baseline data
April-May (2012)	Phase 1 of intervention
June (2012) - Feb(2013)	Phase 2 of the intervention
Feb (2013)- March (2013)	Post-test data collection

What are the risks and benefits of participating?

The evaluation measures will be carried out by trained research assistants. The enhanced school sport sessions will be developed by the research team and delivered by a suitable member of the school's teaching staff. Based on previous studies, students will have no greater chance of injury by participating in these programs in comparison to other sports and physical activities.

The program will provide students with an opportunity to increase their knowledge and skills and improve attitudes toward physical activity and nutrition. Students will also benefit from participation in a variety of enjoyable exercise activities. Staff involved in running these sessions will also personally benefit through acquired knowledge, skills and fitness. These sessions will also provide opportunities for professional development through the provision of resources and programs to assist with session delivery.

Data from lesson observations will be used to determine students' activity levels in PE across all schools and quality of PE (no teachers will be identifiable in final reports). We will also provide personalised feedback to teachers as part of the intervention, but individual class/teacher results will not be shared with the schools.

How will the information collected be used?

The data collected from this study will be used for journal publications and conference presentations and to inform future practice for the design of valuable, evidence-based school sport programs.

How will privacy be protected?

Any personal information provided by students and parents will be confidential to the researchers. The results of the study will be published in general terms and will not allow the identification of individual students or schools. Once the data has been collected, de-identified using participant codes and entered into an electronic data file, questionnaires and other data collection sheets will be destroyed. The electronic data files will be retained for at least 5 years but no individual will be identifiable in the data files or published reports.

What do you need to do to participate?

If you are willing to participate in this study, could you please complete the accompanying Consent Form and return it to the researchers in the reply paid envelope provided. Upon receipt of your consent, a member of the research team will contact you to organise a time to visit the school and provide students with information about the study. If you would like to organise a different route for the dissemination of the Information Sheet and Consent Form to students, please let A/Prof Lubans know. All students will be required to return a Consent Form, which his/her parents/guardians have signed before the study starts.

Further information

Following the completion of the study, the school will be sent a dissemination report describing the findings of the study. It is suggested that the findings are disseminated to students and their parents/guardians via a school newsletter or similar method. Individual results will not be given to the students.

If you would like further information please do not hesitate to contact A/Prof David Lubans. Thank you for considering this invitation.

A/Prof David Lubans	Prof Philip Morgan	Prof Robin Callister
Faculty of Education & Arts School of Education University of Newcastle Phone: (02) 4921 2049 David.Lubans@newcastle.edu.au	Faculty of Education & Arts School of Education University of Newcastle Phone: (02) 4921 7265 Philip.Morgan@newcastle.edu.au	Faculty of Health Biomedical Sciences & Pharmacy University of Newcastle Phone: (02) 4921 5650 Robin.Callister@newcastle.edu.au

Prof Ron Plotnikoff	Mrs Deborah Dewar
Faculty of Education & Arts School of Education University of Newcastle Phone: (02) 4985 4465 Ron.Plotnikoff@newcastle.edu.au	Faculty of Education & Arts School of Education University of Newcastle Phone: (02) 49 854255 Deborah.Dewar@newcastle.edu.au

This project has been approved by the University's and NSW DET Ethics committees,-Approval numbers H-2011-0214 SERAP 2011200. Should you have concerns about your rights as a participant in this research, or you have a complaint about the manner in which the research is conducted, it may be given to the researcher, or, if an independent person is preferred, to the Human Research Ethics Officer, Research Office, The Chancellery, The University of Newcastle, University Drive, Callaghan NSW 2308, Australia, telephone (02) 49216333, email Human-Ethics@newcastle.edu.au.

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Email:

Research Project: Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES)

TEACHER CONSENT FORM

Chief Investigators: A/Prof David Lubans, Prof Philip Morgan, Prof Ron Plotnikoff,

Prof Robin Callister & Mrs Deborah Dewar

I have been given information about the project identified above. I understand that if I consent to my school's involvement in this project, consenting students will participate in the study entitled: *Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES)* and my school will be randomly allocated to one of two interventions:

(i) *The study program recipient group:* where student participants will receive a 6-month physical activity program.

OR

(ii) *The wait-list control group:* where student participants will receive the physical activity program at the end of the study period.

As part of the study I will complete a questionnaire regarding physical activity opportunities in the school environment, and have some of the physical education / sport lessons that I teach observed. I understand that consenting students will also complete the following program evaluation measures: physical activity and movement skills proficiency, height and weight, cardio-respiratory fitness, self-esteem, resilience, and physical activity behaviours. I have had an opportunity to ask A/Prof Lubans questions about the research. I understand that my participation in this research is voluntary and that I and my students are free to withdraw from the research project at any time. My refusal to participate or withdrawal of consent will not affect my relationship with the University of Newcastle.

By signing below I am indicating my consent to participate in this research project conducted by A/Prof David Lubans. I am also consenting for the provision of time and space for (1) members of the research team to deliver information to potential student participants at a recruitment presentation; (2) delivery of the study's intervention components during timetabled PE and school sport and weekly lunch periods which will be supervised by interested school staff (3) members of the research team to collect evaluation measures from student participants and to observe my PE lessons and complete the teacher questionnaire three times during the study period.

Teacher's name: _____

Name of school: _____

Signature: _____ **Date:** _____

PLEASE FAX OR EMAIL COMPLETED SHEET BACK ASAP TO DAVID LUBANS- FAX. No. 49217407 OR David.Lubans@newcastle.edu.au

This project has been approved by the University's and NSW DET Ethics committees,-Approval numbers H-2011-0214 SERAP 2011200. Should you have concerns about your rights as a participant in this research, or you have a complaint about the manner in which the research is conducted, it may be given to the researcher, or, if an independent person is preferred, to the Human Research Ethics Officer, Research Office, The Chancellery, The University of Newcastle, University Drive, Callaghan NSW 2308, Australia, telephone (02) 49216333, email Human-Ethics@newcastle.edu.au.

Appendix 6. Parent information statement and consent form

A/Prof David Lubans
School of Education
Faculty of Education and Arts
University of Newcastle
Callaghan NSW 2308
Phone: + 61 (0)2 4921 2049
Fax: +61 (0)2 4921 7407
Email:

Research Project: Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES)

STUDENT & PARENT INFORMATION STATEMENT

Dear student and parent,

Your school is invited to participate in the research project identified above which is being conducted by A/Prof David Lubans, Prof Philip Morgan, Prof Ron Plotnikoff, Prof Robin Callister and Mrs Deborah Dewar from the University of Newcastle. This research is funded through the Hunter Medical Research Institute.

Why is this research being done?

Low levels of physical activity and high levels of overweight and obesity have contributed to a number of health problems for Australian children. Competency in a range of movement skills (e.g. kicking, running, throwing) is the foundation for an active lifestyle. The aim of this study is to evaluate the impact of a school-based movement skills program on the physical activity behaviour and mental health of primary school children.

Who can participate in this research?

Students in grades 3 and 4 at your child's school and their parents are eligible to participate in this study. We aim to recruit 60 students from each school. Parents will be asked to complete a questionnaire about their children's physical activity. They will also be invited to attend an information evening and participate in school sport sessions.

What choice do you have?

The school principal has agreed to your school being involved in the study. However participation in the study is entirely you and your parent's choice. If you agree to participate you can choose to withdraw from the study at any time and will be free to discontinue participation in the assessments at any time. If you choose to withdraw from the program, you will be provided with alternative physical activity during normal school sport lesson time. A decision not to participate or discontinuation of involvement in the study will not jeopardise your relationship with the University of Newcastle or the school. Withdrawal from this task will not result in any disciplinary action, nor will it affect your academic grades, given that this is a purely voluntary research task.

What is involved in this study?

Schools who agree to participate will be ***randomly allocated*** to either a study program recipient group or a wait list control group. Schools allocated to the wait list control will not receive the study program during the study period. However, program materials will be made available to these schools following completion of the study.

Consenting students from schools receiving the study program will participate in a physical activity and fundamental movement skills program, which will be based at school. The program will run for two full school terms (terms 2 and 3, 2012) and will aim to improve the physical activity behaviours and fundamental movement skills of participants. Students in **BOTH** groups will complete evaluation measures on three

occasions during the study period (baseline, 6- and 12-months). Students who do not consent to participate in the project will be involved in some aspects of the intervention (e.g. enhanced school sport) but will not complete study assessments. Participating parents will complete questionnaires at the start of the study. The program components and evaluation measures are listed below in Table 1.

Table 1: Program components and evaluation strategies

Program components ***(Students from wait-list control schools will not receive program materials until study completion)***	***Evaluation of program*** ***(Measures taken from study participants in BOTH program recipient schools and wait-list control schools).***
The program involves the following five (5) components: i) *Professional development for teachers* (1 x full day for school champions[2], 1 x half day for all teachers at intervention schools) – The research team will deliver professional development workshops for teachers. Workshops will focus on effective teaching methods for the development of FMS, strategies for assessing FMS, increasing ALT and promoting physical activity in PE and school sport. a. *School champion workshop:* will be held at the university. b. *Whole-school workshops:* will be delivered in the study schools during one of their scheduled professional development days. ii) *Student leadership* (1 x 2 hours) – Students will be provided with an opportunity to achieve SCORES leadership accreditation. This will provide students with formal acknowledgment (i.e. certificates) and rewards (i.e. water bottles, stickers and balls) for their participation. SCORES leaders will be encouraged to help organise and deliver lunch and recess activities at school. Workshops will be delivered at the study schools during PE/school sport by the research team. iii) *Community links* (6 x visits) – Community organisations (e.g. local football clubs) will be invited to the visit the study schools during PE/school sport. This will help to promote community sporting links. iv) *Policy and environment* (on-going) – 2 strategies will be used: a. *Policy review and recommendations:* The research team will conduct a review of physical activity policy in the schools. The research team will work with Principals to revise policy to support the physical activity promotion. b. *Equipment and resources:* Each school will be provided with physical activity equipment (e.g. bats, balls etc) and resources (e.g. activity cards) to support the implementation of the intervention based on their individual school needs (approx. $1,000). v) *Parental engagement* – 3 strategies will be used to involve parents: a. *Newsletters* - Parents of study participants will be provided with newsletters to educate and encourage them to support their children's physical activity behaviors. Newsletters will also provide updates and feedback on the project. b. *FMS Homework* – Students will be encouraged to complete practical homework tasks focused on FMS development with their parents/guardians. c. *Parent evening* – Parents will be invited to attend an information session on how to promote and increase physical activity and FMS in the home setting.	*Students* The following measures will be taken 3 times (baseline, 6-months and 12-months): • *Cardio-respiratory fitness:* using the 20m shuttle test. • *Physical activity:* an accelerometer[1] will be worn for 7 days to determine changes in physical activity. • *Fundamental movement skill:* using a standard test (TGMD II) including six locomotor and six object control skills which will be video-taped for assessment. The following measures will be taken 2 times (baseline and 12-months): • *Height:* using a stadiometer. • *Weight:* using a calibrated scale. • *Questionnaires*: assessing self-esteem, resilience, and physical activity behaviours. *Physical education (PE) / sport lesson observations:* • The research team will observe PE/sport lessons and use SOFIT and the SCORES lesson observation form to assess the effectiveness of lessons. *Teachers* • *Questionnaire:* regarding physical activity opportunities in the school environment. *Parents* • *Questionnaires:* regarding children's physical activity and activity-related parenting practices.

Note: FMS = Fundamental Movement Skills; PE = physical education; ALT = active learning time; SCORES = Supporting Children's Outcomes using Rewards, Exercise and Skills; SOFIT = System for Observing Fitness Instruction Time. [1] An accelerometer is a small device that clips to the belt or waistband and is used to measure physical activity. [2] School champions are the classroom teachers of students in the intervention schools.

What are the risks and benefits of participating?

The evaluation measures will be carried out by trained research assistants. The enhanced school sport sessions will be developed by the research team and delivered by a suitable member of the school's teaching staff. Based on previous studies, students will have no greater chance of injury by participating in these programs in comparison to other sports and physical activities. In the event of an injury occurring, the student will immediately be asked to stop participation, and normal school procedures for the management of injury will be followed. The student will not return to participation in the program's physical activities until clearance has been received from a suitable practitioner.

The program will provide students with an opportunity to increase their knowledge and skills and improve attitudes toward physical activity and nutrition. Students will also benefit from participation in a variety of enjoyable exercise activities and as part of the program's delivery will receive a pedometer for the self-monitoring physical activity.

How will the information collected be used?

The data collected from this study will be used for journal publications and conference presentations and to inform future practice for the design of valuable, evidence-based school sport programs.

How will privacy be protected?

Any personal information provided by students and parents will be confidential to the researchers. The results of the study will be published in general terms and will not allow the identification of individual students or schools. Once the data has been collected, de-identified using participant codes and entered into an electronic data file, questionnaires and other data collection sheets will be destroyed. The electronic data files will be retained for at least 5 years but no individual will be identifiable in the data files or published reports.

What do you need to do to participate?

If you are willing to participate in this study, you and your parent(s) will need to complete the accompanying consent forms (Parent and Student) and return them to the school's office or your roll-class teacher as soon as possible.

Further information

Following the completion of the study, the school will be sent a report describing the findings of the study. Results will also be sent via post to study participants and their parents. Individual results will not be given to students. If you would like further information please do not hesitate to contact A/Prof David Lubans. Thank you for considering this invitation.

If you would like further information please do not hesitate to contact A/Prof David Lubans. Thank you for considering this invitation.

A/Prof David Lubans	Prof Philip Morgan	Prof Robin Callister
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This project has been approved by the University's and NSW DET Ethics committees,-Approval numbers H-2011-0214 SERAP 2011200. Should you have concerns about your rights as a participant in this research, or you have a complaint about the manner in which the research is conducted, it may be given to the researcher, or, if an independent person is preferred, to the Human Research Ethics Officer, Research Office, The Chancellery, The University of Newcastle, University Drive, Callaghan NSW 2308, Australia, telephone (02) 49216333, email Human-Ethics@newcastle.edu.au.

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Research Project: Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES)

PARENT CONSENT FORM

Chief Investigators: A/Prof David Lubans, Prof Philip Morgan, Prof Ron Plotnikoff,

Prof Robin Callister & Mrs Deborah Dewar

I have been given information about the project identified above and have discussed it with my child. We understand that if I consent to my child's involvement, he/she will participate in the study entitled: *Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES).* We understand that my child's school will be randomly allocated to one of two interventions:

(i) The study program recipient group: where student participants will receive a 6-month physical activity and fundamental movement skills program.

OR

(ii) The wait-list control group: where student participants will not receive the physical activity and fundamental movement skills program during the study period. However, program materials will be made available following the study's completion.

I understand that my child will complete the following program evaluation measures: physical activity and fundamental movement skills proficiency, height and weight, cardio-respiratory fitness, self-esteem, resilience, and physical activity behaviours. I provide consent for my child to have their movement skills video recorded and assessed. I am aware that I can review and edit the recording of my child's skills upon request. I understand that my child's physical education /sport lessons will be observed by members of the research team. I also understand that I will complete a questionnaire relating to activity relating parenting practices and my child's physical activity. We have had an opportunity to ask A/Prof Lubans questions about the research. I have discussed this project with my child and we understand that their participation in this research is voluntary and that he/she is free to withdraw from the research project at any time. His/her refusal to participate or withdrawal of consent will not affect his/her relationship with the University of Newcastle or the school. Withdrawal from this task will not result in any disciplinary action against my child, nor will it affect his/her academic grades, given that this is a purely voluntary research task.

By signing below I am indicating consent for my child to participate in this research project conducted by A/Prof David Lubans, as it has been described to us in the Information Statement, a copy of which I have retained.

Student name: _____

Parent/guardian name: _____

Signature: _____ **Date:** _____

For the receipt of monthly newsletters providing updated information about the program your child has been participating in, please provide your contact details:

Postal address: _____

Email address: _____ **Home Phone:** _____

Mobile Phone: _____

Please sign the completed consent letter and return with your child's consent letter to school's office or your child's teacher

This project has been approved by the University's and NSW DET Ethics committees,-Approval numbers H-2011-0214 SERAP 2011200. Should you have concerns about your rights as a participant in this research, or you have a complaint about the manner in which the research is conducted, it may be given to the researcher, or, if an independent person is preferred, to the Human Research Ethics Officer, Research Office, The Chancellery, The University of Newcastle, University Drive, Callaghan NSW 2308, Australia, telephone (02) 49216333, email Human-Ethics@newcastle.edu.au.

Appendix 7. Assessment protocol booklet

SCORES

Supporting Children's Outcomes using Rewards, Exercise and Skills

Assessment Protocols Booklet

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

Table of Contents

1. Equipment Checklist

Make sure you have the following equipment organised and packed before visiting the school:

1. 1 x Stadiometers ☐
2. 1 x Weight scales (ensure new batteries + spares) ☐
3. 1 gym mat ☐
4. Beep Test accessories: ☐
   - Beep test CD
   - CD player and extension cord
   - 10 Cones / discs
   - 20m tape measure
   - Post it notes
5. FMS Test accessories: ☐
   - 15 cones / discs
   - 25m of measuring tape (with measurement in feet)
   - Masking Tape
   - Beanbag
   - 1 T-Ball stand
   - 1 Soft T-Ball bat
   - 2 Softballs soft (4 inch (10.16 cm) lightweight ball)
   - 1 Rubber Basket ball
   - 2 Tennis balls
   - 2 Foam Soccer balls
   - 20 Flat disc markers
6. Student Questionnaires: ☐
   - Key dietary behaviours
   - Self-perception
   - Resilience
   - Physical Activity Beliefs
7. Teacher Questionnaires
   - PA opportunities in the school setting ☐
8. Sticker name tags ☐
9. Pencils (1 for each student) & 4 erasers ☐
10. Small White board for recording name and ID ☐
11. String and dumbbells ☐
12. Set square ☐

2. Assessment Recording Sheet

Assessment (circle): **Baseline** **6-month** **12-month**

Date: _____ School: _____ Teacher Name: _____

Student Name: _____ ID: _____

Male / Female DOB: _____ Mobile No. _____

Checklist:

1) Physical activity beliefs questionnaire ☐

2) Self-perception questionnaire ☐

3) Resilience questionnaire ☐

4) Accelerometer distributed & protocol explained ☐

Accelerometer Type (circle): GT1M G3TX G3TX+

Accelerometer ID Number: _____

Assessment	**1st Recording**	**2nd Recording**
Height (cm)		
Weight (kg)		
20m Shuttle Test		

Locomotor movement Skills		**Object-control movement Skills**	
Activity	**Completed**	**Activity**	**Completed**
Run		Dribble	
Hop		Catch	
Leap		Kick	
Gallop		Roll	
Jump		Throw	
Slide		Strike	

3. Accelerometer Protocol

VISIT ONE

Checklist:

- ☐ Accelerometers (Check you have packed the required number of monitors)
- ☐ Accelerometer Master spread sheet
- ☐ Participant information sheet for accelerometers (1 for each student)

Introduction Script

*Thank you for wearing one of our special **"physical activity monitors"**. A physical activity monitor tells us how much physical activity you do over the next week and how hard or easy you are working when being physically active. Today we're going to tell you how your monitor works, when you SHOULD and SHOULD NOT wear it, and show you how to put one on. You get to keep one of these special monitors for the week so it's very important that you take good care of it. Next week we will collect your monitor back from you. You will be provided with a reward for bringing it back on time.*

Instructions:

1. Distribute the ***Activity Monitor Information Sheet*** (see below) and go through with the students. DO NOT GIVE OUT MONITORS AT THIS STAGE.

2. Have students turn to the monitor log (see below). Have students fill out the information at the top of the log sheet and the days of the week across the top of the log table – starting from tomorrow. For example, if the monitors are distributed to students on a Monday, they are to start filling out the log on Tuesday. Briefly show students how to fill out the log but instruct that mum or dad will need to help them complete it at the <u>end of each day</u>.

3. Give each student a monitor.

4. Ask each student to put on their own monitor. Explain that once it is fitted correctly they should put it underneath their clothes (i.e. on their skin or on waist band of shorts/skirt). Ask students to check the accelerometer is:

i. firm (does not bounce but shouldn't be uncomfortably tight)
ii. sticker facing upwards (pointing towards the sky)
iii. on the hip (in line with the knee)

5. Tell the students that they should ***BEHAVE NORMALLY*** and not do extra physical activities just because they are wearing the monitor, but also not to stop doing things because of wearing the monitor. <u>Reinforce that they are not to swap monitors with another student.</u>

6. Explain that prizes will be given to those students who wear their monitor for the whole week <u>and</u> return it on time.

7. Check that each student's accelerometer to make sure it is on properly using the above criteria.

8. **IMPORTANT:** The ID number on the back of each student's monitor needs to be recorded on the coloured ***MASTER SHEET*** (see below) as well as on the student's monitor log sheet. Parent's home or mobile number will also need to be recorded on the ***MASTER SHEET.*** Be careful when writing down monitor ID and phone numbers as one incorrect digit makes it extremely difficult to track that monitor.

9. Finally, ask the students some prompt questions regarding their accelerometer such as:

i. When do you wear it?
ii. When don't you wear it?
iii. What do you write on the log?

10. Ensure that students put the information sheet and activity log in their school bag and reinforce the importance of passing this onto mum or dad when they get home.

11. Organise a day with the liaison teacher for when you will return to collect monitors.

Ensure you leave a copy of the master sheet with the liaison teacher so that they can keep track of which students have returned their activity monitors at the end of the 7-day period.

Have you gone through the following with the students?

Sticker facing up	☐
On the (preferred) hip in direct line with the knee	☐
Firm	☐
Off – bed and water	☐
Maintain normal activities	☐
Filling in log	☐
Prizes	☐
Check each accelerometer	☐
Record monitor ID and phone number accurately on ***MASTER SHEET***	☐

VISIT TWO (one week later):

Checklist:

- ☐ Master spreadsheet of student's details
- ☐ Pencils
- ☐ Accelerometers (for any students away on first visit)
- ☐ Accelerometer information sheets and logs (for any students away on first visit)

Instructions:

1. Distribute monitors to students who were absent during initial distribution. Go through steps 1-10 as above.
2. Ensure these new students are added to the ***MASTER SHEET*** (including monitor ID, phone numbers and date of distribution)***.***
3. Collect returned monitors from the liaison teacher. Check off returned monitors against the ***MASTER SHEET***. Emphasise the importance of school staff chasing up monitors that have not been returned.
4. Leave a record with the liaison teacher showing students who are yet to return their activity monitor or who have just been distributed a monitor. Organise a day with the liaison teacher for when you will return to collect monitors.

Have you:

- Collected returned accelerometers and logs ☐
- Checked each returned accelerometer no. matches number on master spreadsheet ☐
- Distributed accelerometers to absent students (see VISIT ONE) ☐

INFORMATION SHEET

PHYSICAL ACTIVITY MONITOR

Dear parent/guardian,

Thank you for consenting to your child's involvement in the SCORES project conducted by the University of Newcastle. Your child has been asked to wear a physical activity monitor for one week (7 days) to assist with this research. Please find below an explanation of your child's monitor. Please do not hesitate to call Tara Finn on (02) 49216299 if you have any questions.

What does the physical activity monitor do?
When worn, the monitor records all movement by duration and intensity. The monitor can detect how much time is spent participating in activities of varying intensities (e.g. sitting, walking, running).

How long should my child where the monitor for?
We would like your child to wear the monitor for 7 days (including week and weekend days) for all waking hours. It is important that s/he behaves normally and does not try to do more activity than usual simply because they are wearing the device.

How is the monitor to be positioned when being worn?
- The monitor is to be positioned on the front of the hip - directly in line with the knee. The monitor can be worn under clothing to keep discreet.
- Make sure the monitor is NOT upside down - the sticker on the top of the monitor should be facing upwards i.e. pointing towards the sky.
- The elastic belt should fit firmly but not feel uncomfortable.

When to take the monitor OFF.
The monitor should be taken off when your child goes to bed at night, or if there is a chance that the monitor could get wet (e.g. swimming, showering). **THE MONITORS ARE NOT WATER PROOF.**

Why do I need to help my child complete the daily activity log?
The activity log (see over page) tells us important information about when you're child wore the monitor and why it was taken off (e.g. for a shower). To complete the log have your child:
- For each day shade in the hours when they were wearing the monitor. Hours which are NOT shaded in indicate the monitor was not worn (e.g. when sleeping or showering).
- Note any specific time periods that the monitor was taken off and why (e.g. 3.30-4.30pm on Wednesday – Swimming).
- Indicate on the log if they participated in any of the following activities and for how long (these activities are not easily detected by the monitor so it's important that they are recorded on the log):
    * Riding a bike
    * Jumping on a trampoline
    * Riding a scooter

What do I do at the end of the 7 days?
Your child will need to return their monitor to the class teacher. The due date for returning this monitor has been recorded at the top of the log sheet (next page). It is VERY IMPORTANT that the monitor is returned to school in its due date.

The monitors are expensive, so please take care of them. It is quite a sturdy piece of equipment, but will be damaged if thrown or forcefully dropped. You should not lose the monitor if worn during all waking hours because it is securely fitted to a belt.

ACTIVITY MONITOR LOG SHEET

Name …… **Monitor ID Number** ……..……..…….

School …….. **Date to be returned to school** ……..

INSTRUCTIONS:

1. Please shade in the hours during which the activity monitor was WORN
2. When the monitor was NOT WORN please indicate what you were doing and how long the monitor was not worn for (e.g. showering – 30 min).
3. Please indicate any time spent swimming, riding a bike or scooter, or playing on a trampoline.

See the example on the left hand side of the page for how to complete the log.

EXAMPLE:

	Time	Monday
Morning Hours	12-1	Sleep
	1-2	Sleep
	2-3	Sleep
	3-4	Sleep
	4-5	Sleep
	5-6	Sleep
	6-7	Sleep
	7-8	**PUT ON**
	8-9	**BIKE RIDING (30 min)**
	9-10	
	10-11	
	11-12	
Afternoon / Night hours	12-1	
	1-2	
	2-3	
	3-4	**TAKEN OFF SWIM (40 min)**
	4-5	**TAKEN OFF SHOWER (20 min)**
	5-6	**PUT ON**
	6-7	
	7-8	
	8-9	
	9-10	**TAKEN OFF BED**
	10-11	Sleep
	11-12	Sleep

		Day of the week						
	Time							
Morning Hours	12-1							
	1-2							
	2-3							
	3-4							
	4-5							
	5-6							
	6-7							
	7-8							
	8-9							
	9-10							
	10-11							
	11-12							
Afternoon / Night hours	12-1							
	1-2							
	2-3							
	3-4							
	4-5							
	5-6							
	6-7							
	7-8							
	8-9							
	9-10							
	10-11							
	11-12							

MASTER SHEET - Accelerometer tracking

School: ______________________________ Date: ___________

Assessment (circle): Baseline 6–month 12–month

ID	Name	Accel Type	Accel. No.	Parents phone no.	Date Distributed	Date Returned

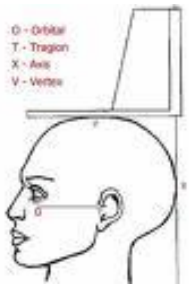
4. Height

Equipment required: Stadiometer.

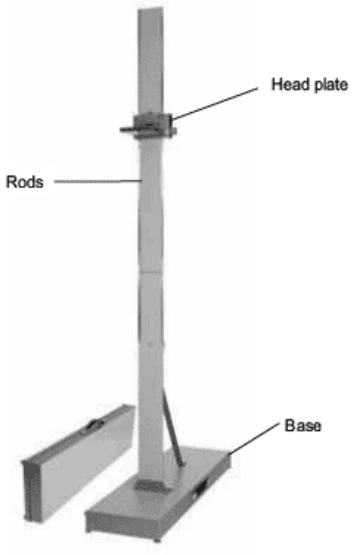
Ensure: The floor is hard and level.

Instructions:

- Shoes and socks off
- Step onto stand with back to column
- Feet together (heels together)
- Ideally heels, buttocks and upper back touch the vertical post
- Stand up straight (tall) hands down by sides
- Look straight ahead



- Breathe in and hold breath
- Bring headboard down and crush hair to firmly contacting the persons head and level (horizontal to ground). Girls may need to take hair out if up.
- Make sure heels do not lift off floor
- Record height to nearest 0.1 of cm
- Get person to step off stand
- If values differ by more than 0.3 cm repeat again



5. Weight

Equipment Required: Electronic digital scales

Ensure: Scales have been calibrated, and the floor is hard and level.

Instructions:

- Turn scale on and ensure zeroed 0.00 (if required)
- Shoes off, minimal clothing, all objects out of pockets, belt off, heavy jewellery off (watches, necklaces)
- Record clothing worn on data sheet (may account for fluctuations)
- Instruct student to step onto middle of scale with feet slightly apart and stand very still with weight evenly balanced on both feet
- Record weight to 0.01 kg
- Step off
- Repeat
- If values differ by more than 0.1 kg repeat again

6. Fundamental Movement Skills

Explanation:

General set up before children arrive:
Camera 1 – Locomotor Skills

- In an open area measure 8 metres of clear space and set up 2 cones at each end (cone A and cone B). Find the centre and place another cone.
- Measure 8 metres perpendicular to the middle cone and place tripod. Mount camera on tripod.
- Camera must be zoomed all the way out and when looking through the view finder you must be able to see both cone A and cone B.
- Check power to video is on, check camera on, pause.

Data Collection:
Camera 1 – Locomotor Skills

- Have children waiting in cue to side of cone 1
- Ensure child is in position.
- Video the children saying their first and last name;
- Put the student ID card in front of the camera so that the date, school, teacher name, child's name and id number can been seen.
- To cue child to begin movement say 'ready, set, go', start the camera on 'ready' to ensure all movement is caught, and pause once all of movement is finished.
- Pause tape between students. Digital footage is electronically backed-up so pausing reduces size of file and also edits each trial into a single clip ready for storage.

Camera 2 – Object Control Skills

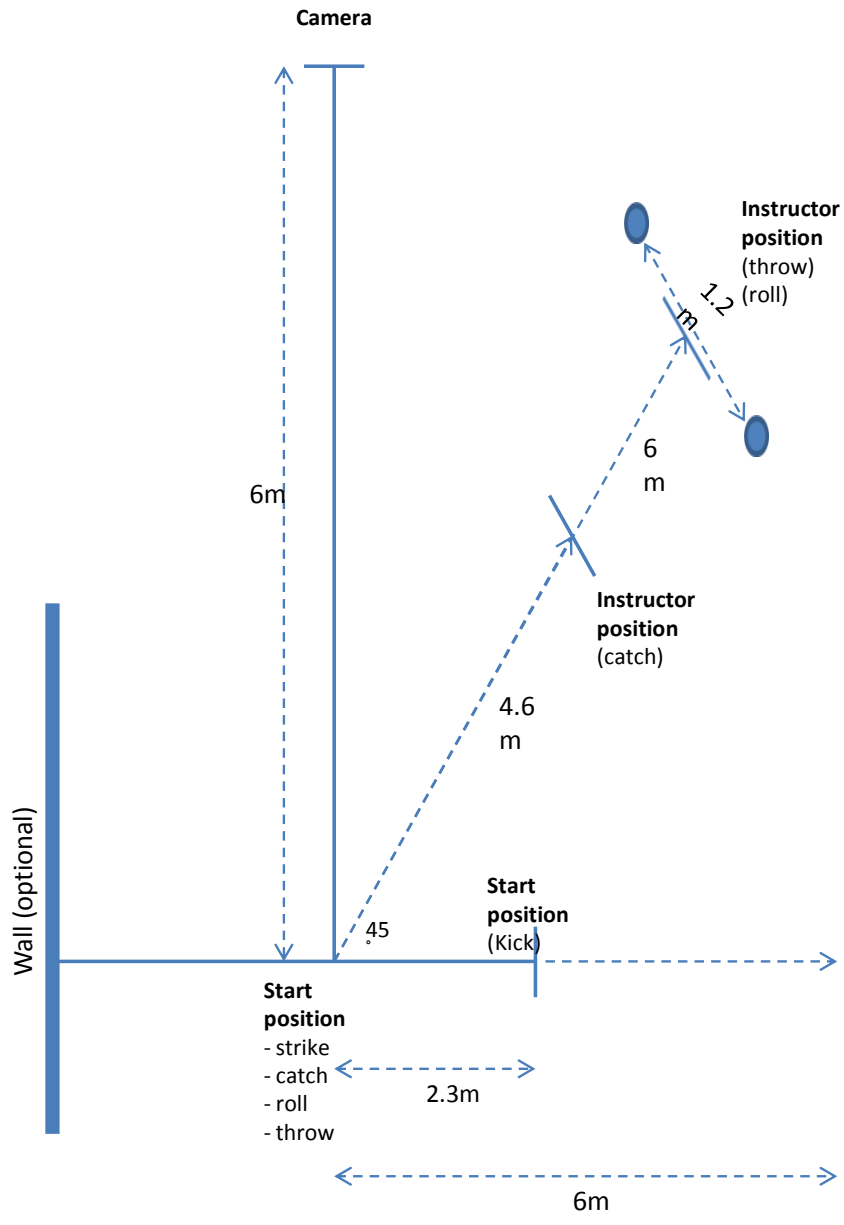
- Measure 6m perpendicular to the cone and place tripod. Mount camera on tripod.
- Camera must be zoomed all the way out and when looking through the view finder you must be able to see both cones A and B, (cones A & B are 6m apart).
- Check power to video is on, check camera on, pause.

Data Collection:
Camera 2 – Object Control Skills

- Have children waiting in cue to side of cone 1
- Ensure child is position
- Video the children saying their first and last name;
- Put the student ID card in front of the camera so that the date, school, teacher name, child's name and id number can been seen.
- To cue child to begin movement say 'ready, set, go', start the camera on 'ready' to ensure all movement is caught, and pause once all of movement is finished.
- Pause tape between students. Digital footage is electronically backed-up so pausing reduces size of file and also edits each trial into a single clip ready for storage.

Note: Participants are to be excluded from the measure if they are injured. Please record any injuries on the student's assessment recording sheet.

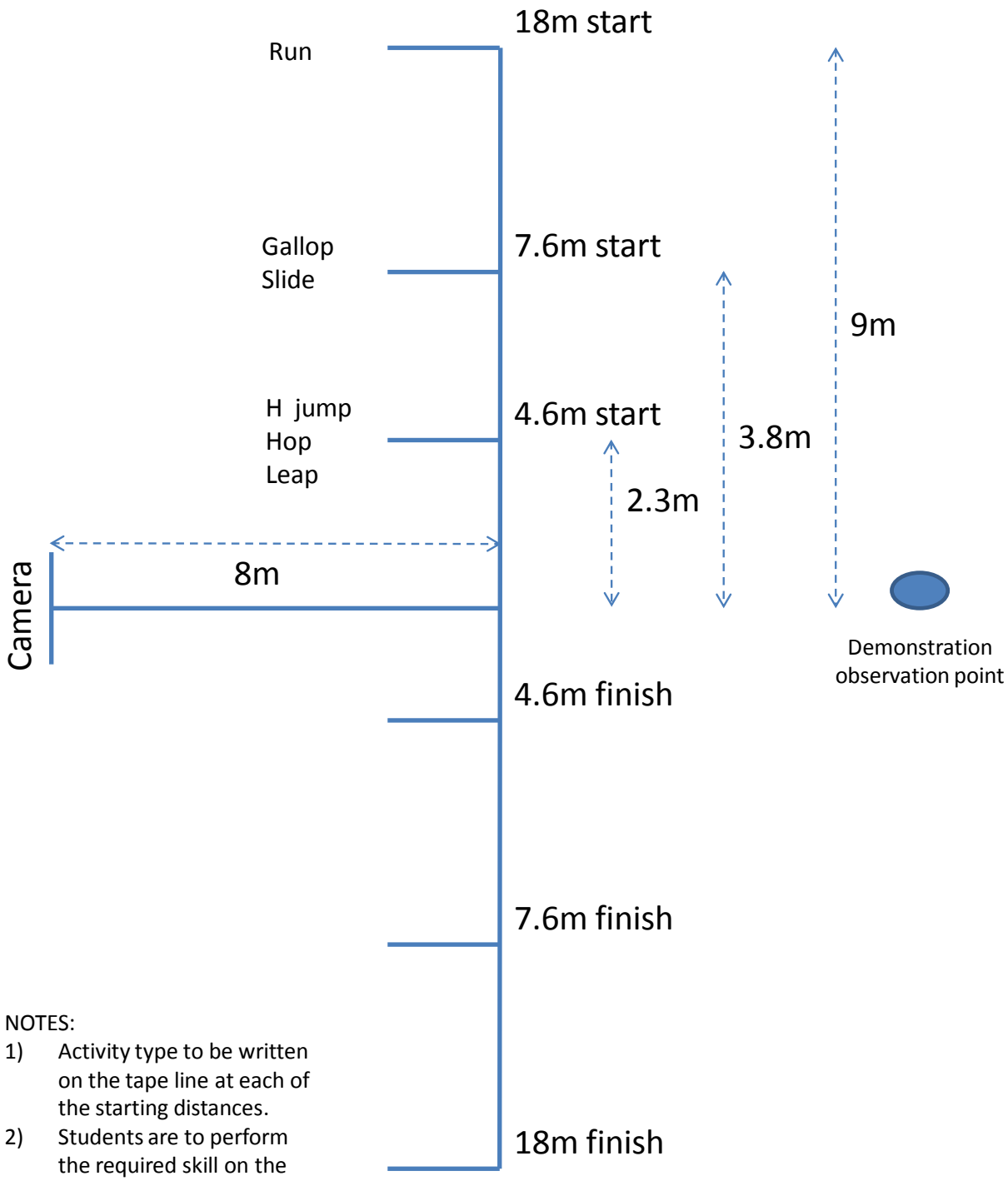
Floor layout for Fundamental Movement Skills Assessment – Object Control



Note:
i)The FMS identified under **'instructor position'** is the skill to be performed by the participant.

= cone

Floor layout for Fundamental Movement Skills Assessment – Locomotor



NOTES:

1) Activity type to be written on the tape line at each of the starting distances.
2) Students are to perform the required skill on the side of the tape line farthest from the camera.

Master Spreadsheet
Locomotor Skills Tracking Sheet

School: _____ Date: _____

Class: _____

Assessment (circle): Baseline 6–month 12–month

ID	STUDENT NAME	RUN	HOP	LEAP	GALLOP	JUMP	SLIDE

Master Spreadsheet
Object-control Skills Tracking Sheet

School: ______________________________________ Date: _____________

Class: ______________________________________

Assessment (circle): Baseline 6–month 12–month

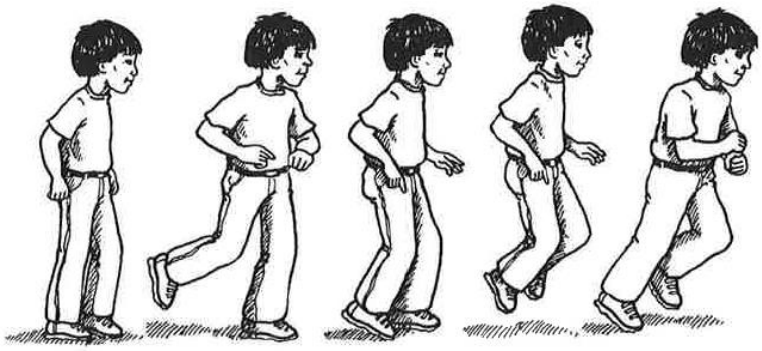
ID	STUDENT NAME	DRIBBLE	CATCH	KICK	ROLL	THROW	STRIKE

Locomotor Skills Instructions:

Locomotor Skills Assessors Criteria

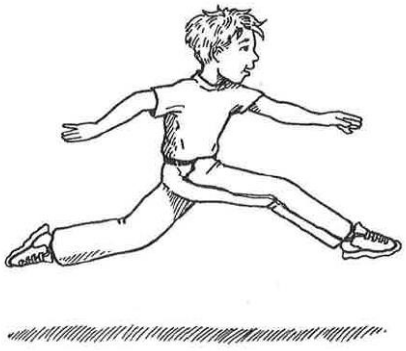
Skill	Materials	Directions	Performance Criteria
1. Run	18.3 m (60 feet) of clear space, and two cones	Place two cones 15.24m (50 ft)) apart. Make sure there is at least 2.5-3.0 m (8 -10 ft) of space beyond the second cone for a safe stopping distance. Tell the child to run as fast as he or she can from one cone to the other when you say "GO" Repeat a second trial.	1. Arms move in opposition to legs, elbows bent 2. Brief period where both feet are off the ground 3. Narrow foot placement landing on heel or toe (i.e not flat footed) 4. Nonsupport leg bent approximately 90 degrees (ie. Close to buttock)

Skill	Materials	Directions	Performance Criteria
2. Gallop	7.6m (25 ft) of clear space, and tape or two cones	Mark off a distance of 7.6m (25 ft) with two cones or tape. Tell the child to gallop from one cone to the other. Repeat a second trial by galloping back to the original cone.	1. Arms bent and lifted to waist level at take off 2. A step forward with the lead foot followed by a step with the trailing foot to a position adjacent to or behind the lead foot 3. Brief period when both feet are off the floor 4. Maintains a rhythmic patter for four consecutive gallops

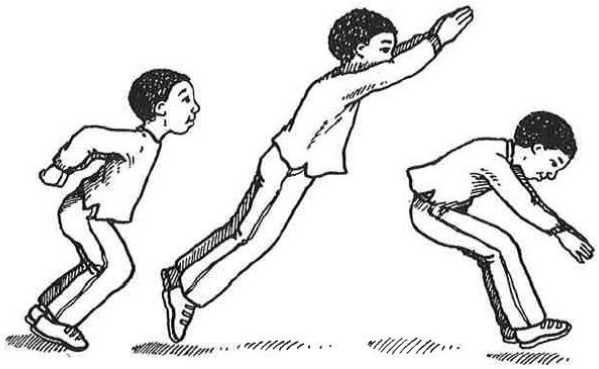


Skill	Materials	Directions	Performance Criteria
3. Hop	A minimum of 4.6m (15 ft) of clear space	Tell the child to hop three times on his or her preferred foot (established before testing) and then three times on the other foot. Repeat a second trial	1. Nonsupport leg swings forward in pendular fashion to produce force 2. Foot of nonsupport leg remains behind body 3. Arms flexed and swing forward to produce force 4. Takes off and lands three consecutive times on preferred foot 5. Takes off and lands three consecutive times on nonpreferred foot

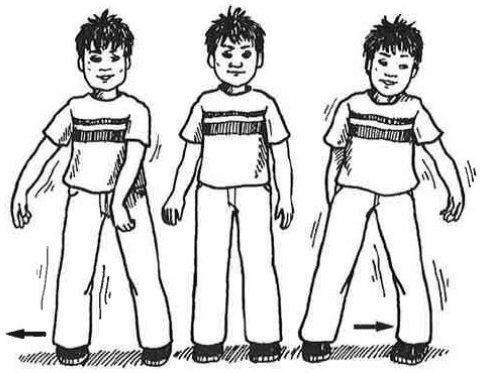
Skill	Materials	Directions	Performance Criteria
4. Leap	A minimum of 6.1 m (20 ft) of clear space, a beanbag, and tape	Place a beanbag or cone on the floor. Attach a piece of tape on the floor so it is parallel to and 3.05 m (10 ft) away from the beanbag. Have the child stand on the tape and run up and leap over the beanbag. Repeat a second trial	1. Take off on one foot and land on the opposite foot 2. A period where both feet are off the ground longer than running 3. Forward reach with the arm opposite the lead foot



Skill	Materials	Directions	Performance Criteria
5. Horizontal Jump	A minimum of 3.05m (10 ft) of clear space and tape	Mark off a starting line on the floor. Have the child start behind the line. Tell the child to jump as far as he or she can. Repeat a second trial.	1. Preparatory movement includes, flexion of both knees with arms extended behind body 2. Arms extend forcefully forward and upward reaching full extension above the head 3. Take off and land on both feet simultaneously 4. Arms are thrust downward during landing



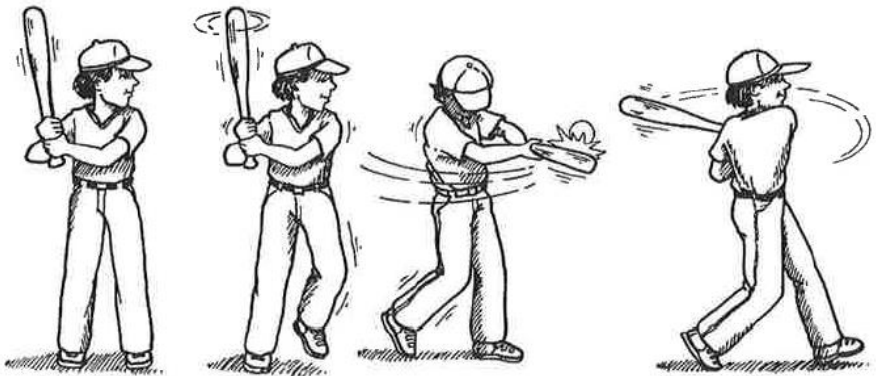
Skill	Materials	Directions	Performance Criteria
6. Slide	A minimum of 7.6m (25 ft) of clear space, a straight line, and two cones	Place the cones 7.6m (25 ft) apart on top of a line on the floor. Tell the child to slide from one cone to the other and back. Repeat a second trial.	1. Body turned sideways so shoulders are aligned with the line on the floor 2. A step sideways with lead foot followed by a slide of the trailing foot to a point next to the lead foot 3. A minimum of four continuous step-slide cycles 4. A minimum of four continuous step-slide cycles to the left



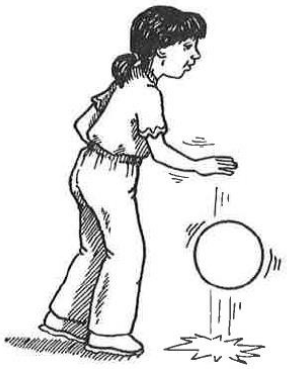
Object-control Skills Instruction:

Object Control Skills Assessors Criteria

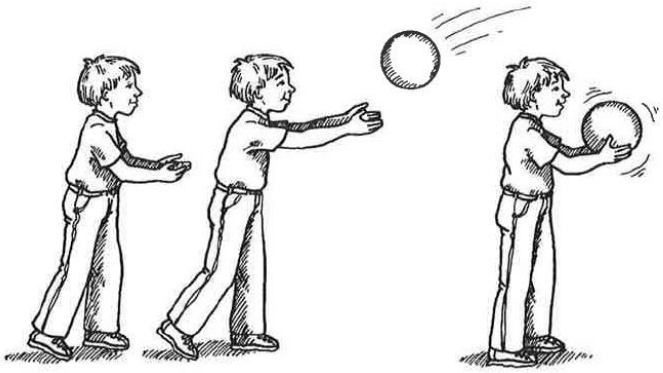
Skill	Materials	Directions	Performance Criteria
1. Striking a Stationary Ball	A 10cm (4 inch) lightweight ball, a plastic bat, and a batting tee	Place the ball on the batting tee at the child's belt level. Tell the child to hit the ball hard. Repeat a second trial	1. Dominant hand grips bat above nondominant hand 2. Nonpreferred side of body faces the imaginary tosser with feet parallel 3. Hip and shoulder rotation during swing 4. Transfers body weight to front foot 5. Bat contacts ball



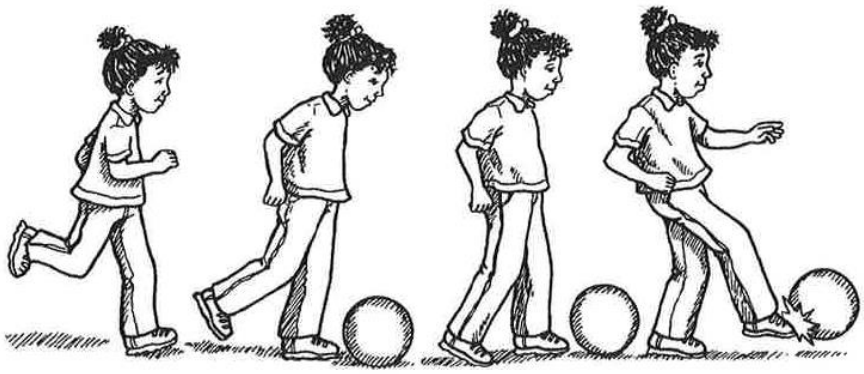
Skill	Materials	Directions	Performance Criteria
2. Stationary Dribble	A 20-25cm (8-10 inch) playground ball for childrens ages 3 to 5; a basket ball for children ages 6-10; and a flat, hard surface	Tell the child to dribble the ball four times without moving his or her feet, using one hand, and then stop by catching the ball. Repeat a second trial.	1. Contacts ball with one hand a about belt level 2. Pushes ball with fingertips (not a slap) 3. Ball contacts surface in front of or to the outside of foot on the preferred side 4. Maintains control of ball for four consecutive bounces without having to move the feet to retrieve it.



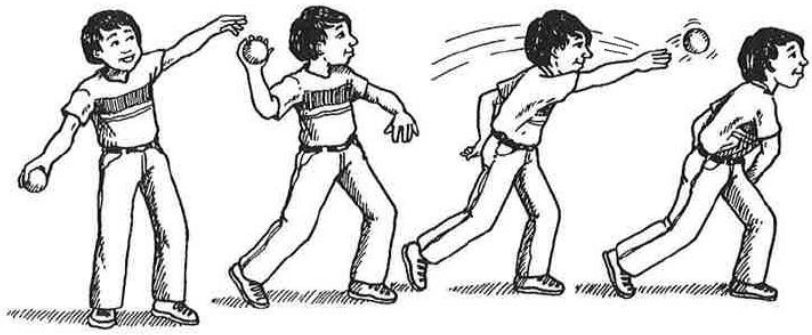
Skill	Materials	Directions	Performance Criteria
3. Catch	A 10cm (4 inch) plastic ball, 4.6m (15 ft) of clear space, and tape	Mark off two lines 4.6m (15 ft) apart. The child stands on one line and the tosser on the other. Toss the ball underhand directly to the child with a slight arc aiming for his or her chest. Tell the child to catch the ball with both hands. Only count those tosses that are between the child's shoulders and belt. Repeat a second trial	1. Preparation phase where hands are in front of the body and elbows are flexed 2. Arms extend while reaching for the ball as it arrives 3. Ball is caught by hands only



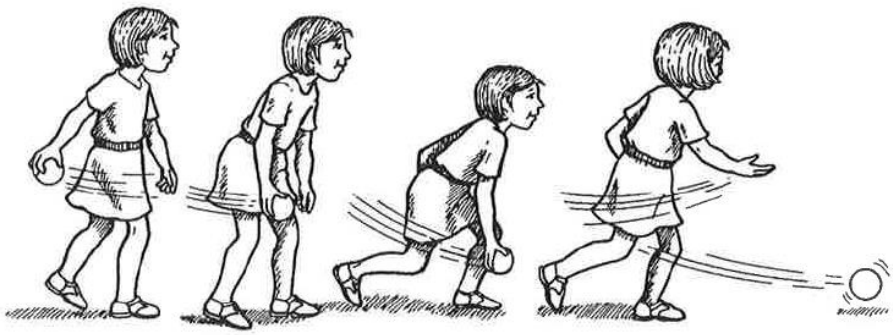
Skill	Materials	Directions	Performance Criteria
4. Kick	A 20-25cm (8-to 10 inch) plastic, playground, or soccer ball; a beanbag; 9m (30 ft) of clear space; and tape	Mark off one line 9m (30 ft) away from a wall and another line 6m (20 ft) from the wall. Place the ball on top of the beanbag on the line nearest the wall. Tell the child to stand on the other line. Tell the child to run up and kick the ball hard toward the wall. Repeat a second trial.	1. Rapid continuous approach to the ball 2. An elongated stride or leap immediately prior to ball contact 3. Nonkicking foot placed even with or slightly in back of the ball 4. Kicks ball with instep of preferred foot (shoe-laces) or toe



Skill	Materials	Directions	Performance Criteria
5. Overhand Throw	A tennis ball, a wall, tape, and 6m (20 ft) of clear space	Attach a piece of tape on the floor 6m (20 ft) from a wall. Have the child stand behind the 6m (20 ft) line facing the wall. Tell the child to throw the ball hard at the wall. Repeat a second trial.	1. Windup is initiated with downward movement of hand/arm 2. Rotates hip and shoulders to a point where the nonthrowing side faces the wall 3. Weight is transferred by stepping with the foot opposite the throwing hand 4. Follow-through beyond ball release, diagonally across the body toward the nonpreferred side



Skill	Materials	Directions	Performance Criteria
6. Underhand Roll	A tennis ball for children ages 3-6; a softball for children ages 7 to 10; two cones; tape; and 7.6m (25 ft) of clear space	Place the two cones against a wall so they are 1.2m (4 ft) apart. Attach a piece of tape on the floor 6m (20 ft) from the wall. Tell the child to roll the ball hard so that it goes between the cones. Repeat a second trial.	1. Preferred hand swings down and back, reaching behind the trunk while chest faces cones 2. Strides forward with foot opposite the preferred hand toward the cones 3. Bends knees to lower body 4. Releases ball close to the floor so ball does not bounce more than 4 inches high



7. 20m Shuttle Test

Explanation: The Beep test is a 20m multistage fitness test to assess running aerobic fitness.

Note: Participants are to be excluded from the measure if they are injured. Please record any injuries on the student's assessment recording sheet.

Instructions:

- Participants are required to run between two lines 20m apart, while keeping pace with audio signals (i.e., the beep) emitted from a pre-recorded CD.
- Participants are to run in a straight line, to pivot on completing a shuttle, and to pace themselves in accordance with the audio signals (i.e., the beep).
- The test is finished when the participant fails to reach the end lines concurrent with the audio signals on two consecutive occasions. Otherwise the test ends when the participant stops because of fatigue.
- All measurements are carried out under standardised conditions on an indoor rubber floored gymnasium.
- The participants are encouraged to keep running as long as possible throughout the course of the test.
- The last completed stage or half-stage at which the participant drops out is scored.

BEEP TEST CLASS LIST

Date: _____

School: _____

Class: _____

Assessment (circle): Baseline 6-months 12-months

Where is test being performed: basketball court/school hall/ other

ID	STUDENT NAME	BEEP TEST LEVEL

8. Questionnaires

Questionnaires (copies included in following sections):

- Self-Perception questionnaire
- Resilience questionnaire
- Physical activity beliefs questionnaire

Instructions:

- Students will complete the questionnaire in the classroom with desks arranged to ensure privacy.
- Provide students with a pencil and eraser.
- The questionnaires will be teacher guided.
- Instructions will be read with students (on inside cover of questionnaires) to ensure they understand.
- Assist students where necessary (e.g., unsure what an item means).
- Reinforce:
  - Students should answer honestly.
  - Raise hand if unsure about an item.
  - This is not a test. There are no wrong answers.
- When collecting questionnaires back ensure name is on front cover.

Appendix 8. Student questionnaires

FOR OFFICE USE ONLY- P/ I.D.

Supporting Children's Outcomes using Rewards, Exercise and Skills

SCORES

'What I Am Like' Questionnaire

Student Name: _____

Identification number: _____

School:_____

Your teacher's name:_____

To protect your privacy this cover sheet will be removed and destroyed once you have been allocated a study number.

Background information

1) **Age:** _____

(Please write)

2) **Month you were born:** _____ **Year you were born**: _____

(Please write) *(Please write)*

3) **Gender:** *please tick* (✓)

☐ Male ☐ Female

4) **Grade at school:** *Please tick* (✓)

☐ Grade 3

☐ Grade 4

5) **What is your cultural background?**

☐ Australian ☐ Asian ☐ European ☐ Middle Eastern

☐ African ☐ Other: (please specify) _____

6) **What language do you speak most at home?** *Please tick* (✓)

☐ **English**

☐ **Another language - (please specify):** _____

7) Are you of **Aboriginal** or **Torres Strait Islander** descent? *Please tick* (✓)

Yes ☐ No ☐

8) **What is the name of the suburb you live in?** _____

What I Am Like - an example question

WHAT AM I LIKE?

- ❖ These are statements which allow people to describe themselves.
- ❖ There are no right or wrong answers since people differ a lot.
- ❖ First, decide which one of the two statements best describes you.
- ❖ Then, go to that side of the statement and tick if it is just "Sort of True" or "Really True" FOR YOU.

Really True for Me	Sort of True for Me	EXAMPLE			Sort of True for Me	Really True for Me
☐	☐	Some kids would rather play outdoors in their spare time	BUT	Others kids would rather watch TV.	✓	☐

REMEMBER to check only ONE of the four boxes

Now some questions about how you feel about yourself…

Really True for Me	Sort of True for Me	REMEMBER to check only ONE of the four boxes			Sort of True for Me	Really True for Me
1. ☐	☐	Some kids do very well at all kinds of sports	BUT	Other kids don't feel that they are very good when it comes to sports.	☐	☐
2. ☐	☐	Some kids are often unhappy with themselves	BUT	Other kids are pretty pleased with themselves.	☐	☐
3. ☐	☐	Some kids wish they could be a lot better at sports	BUT	Other kids feel they are good enough at sports.	☐	☐
4. ☐	☐	Some kids don't like the way they are leading their life	BUT	Other kids do like the way they are leading their life.	☐	☐
5. ☐	☐	Some kids think they could do well at just about any new sports activity they haven't tried before	BUT	Other kids are afraid they might not do well at sports they haven't ever tried.	☐	☐
6. ☐	☐	Some kids are happy with themselves as a person	BUT	Other kids are often not happy with themselves.	☐	☐
7. ☐	☐	Some kids feel that they are better than others their age at sports	BUT	Other kids don't feel they can play as well.	☐	☐
8. ☐	☐	Some kids like the kind of person they are	BUT	Other kids often wish they were someone else.	☐	☐

Really True for Me	Sort of True for Me	REMEMBER to check only ONE of the four boxes			Sort of True for Me	Really True for Me
9. ☐	☐	In games and sports some kids usually watch instead of play	BUT	Other kids usually play rather than just watch.	☐	☐
10. ☐	☐	Some kids are very happy being the way they are	BUT	Other kids wish they were different.	☐	☐
11. ☐	☐	Some kids don't do well at new outdoor games	BUT	Other kids are good at new games right away.	☐	☐
12. ☐	☐	Some kids are not very happy with the way they do alot of things	BUT	Other kids think the way they do things is fine.	☐	☐

FOR OFFICE USE ONLY- P/ I.D.

Supporting Children's Outcomes using Rewards, Exercise and Skills

SCORES

Resilience Questionnaire

Student Name: _____

Identification number: _____

School:_____

Your teacher's name:_____

To protect your privacy this cover sheet will be removed and destroyed once you have been allocated a study number.

Please circle a number indicating how much you 'Disagree' or 'Agree' with each

	Not at all	A little	Some-what	Quite a bit	A lot
1. I have people I look up to	1	2	3	4	5
2. I cooperate with people around me	1	2	3	4	5
3. Getting an education is important to me	1	2	3	4	5
4. I know how to behave in different social situations	1	2	3	4	5
5. My parent(s)/caregiver(s) watch me closely	1	2	3	4	5
6. My parent(s)/caregiver(s) know a lot about me	1	2	3	4	5
7. If I am hungry, there is enough to eat	1	2	3	4	5
8. I try to finish what I start	1	2	3	4	5
9. People think that I am fun to be with	1	2	3	4	5
10. I talk to my family/caregiver(s) about how I feel	1	2	3	4	5

	Not at all	A little	Some-what	Quite a bit	A lot
11. I am able to solve problems without harming myself or others (e.g. by using drugs and/or being	1	2	3	4	5
12. I feel supported by my friends	1	2	3	4	5
13. I know where to go in my community to get help	1	2	3	4	5
14. I feel I belong at my school	1	2	3	4	5
15. My family stands by me during difficult times	1	2	3	4	5
16. My friends stand by me during difficult times	1	2	3	4	5
17. I am treated fairly in my community	1	2	3	4	5
18. I have opportunities to show others that I am becoming an adult and can act responsibly	1	2	3	4	5
19. I am aware of my own strengths	1	2	3	4	5
20. I think it is important to help out in my community	1	2	3	4	5
21. I feel safe when I am with my family/caregiver(s)	1	2	3	4	5

	Not at all	A little	Some-what	Quite a bit	A lot
22. I have opportunities to develop skills that will be useful later in life (like job skills and skills to care for	1	2	3	4	5
23. I enjoy my family's/caregiver's cultural and family traditions	1	2	3	4	5
24. I enjoy my community's traditions	1	2	3	4	5
25. I am proud to be (Nationality: _____)?	1	2	3	4	5

FOR OFFICE USE ONLY- P/ I.D.

Supporting Children's Outcomes using Rewards, Exercise and Skills

SCORES

Physical Activity Beliefs

Student Name: _____

Identification number: _____

School:_____

Your teacher's name:_____

To protect your privacy this cover sheet will be removed and destroyed once you have been allocated a study number.

Study ID_____

Sedentary behaviour

DURING A TYPICAL WEEK, how many hours a day do you usually do the following things in your free time?	**Never**	**Approx 1/2 hour**	**Approx an hour**	**Approx 2 hours**	**Approx 3 hours**	**Approx 4 hours**	**Approx 5 hours**	**Approx 6 hours**	**Approx 7 hours or more**
1) Watch TV or videos or DVDs on school days?	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
2) Watch TV or videos or DVDs on weekends?	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
3) Use a computer for playing games or use console on school days?	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
4) Use a computer for playing games or use console on weekends?	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
5) Use a computer for: chatting online, internet, on school days?	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
6) Use a computer for: chatting online, internet, on weekends?	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

Physical activity social support

DURING A TYPICAL WEEK, how often has a member of your household: (For example, your father, mother, brother, sister, grandparent, or other relative)	**Never**	**Once**	**Some times**	**Almost every day**	**Everyday**
1) Encouraged you to do physical activities or play sports?	**1**	**2**	**3**	**4**	**5**
2) Done a physical activity or played sports with you?	**1**	**2**	**3**	**4**	**5**
3) Provided transportation to a place where you can do physical activities or play sports?	**1**	**2**	**3**	**4**	**5**
4) Watched you participate in physical activities or sports?	**1**	**2**	**3**	**4**	**5**
5) Told you that you are doing well in physical activities or sports?	**1**	**2**	**3**	**4**	**5**

DURING A TYPICAL WEEK, how often:	**Never**	**Not Often**	**Neutral**	**Often**	**Always**
6) Do you encourage your friends to do physical activities or play sports?	**1**	**2**	**3**	**4**	**5**
7) Do your friends encourage you to do physical activities or play sports?	**1**	**2**	**3**	**4**	**5**
8) Do your friends do physical activities or play sports with you?	**1**	**2**	**3**	**4**	**5**
9) Do other kids tease you for not being good at physical activity or sports?	**1**	**2**	**3**	**4**	**5**
10) Do friends tell you that you are doing well in physical activities or sports?	**1**	**2**	**3**	**4**	**5**

Prochaska, J.J., Rodgers, M.W., and Sallis, J.F. (2002). Association of parent and peer support with adolescent physical activity. *Research Quarterly for Exercise and Sport*, 73, 206-210.

Study ID_____

Social support in PE and school sport

	Never	Not Often	Neutral	Often	Always
During PE and school sport my teacher:					
1) Appears enthusiastic about the activity	1	2	3	4	5
2) Teaches me valuable movement skills (e.g. how to throw and catch)	1	2	3	4	5
3) Participates in the physical activity or sport with me	1	2	3	4	5
4) Makes the activity enjoyable	1	2	3	4	5
5) Encourages me to participate in the activity	1	2	3	4	5

Lubans, D. R., Morgan, P. J., & McCormack, A. (2011). Adolescents and school sport: The relationship between beliefs, social support and physical self-perception. *Physical Education & Sport Pedagogy, 16*(3), 237-250.

Study ID_____

Enjoyment

When I am active……	Disagree a lot	Disagree	Neutral	Agree	Agree a lot
1. I enjoy it	1	2	3	4	5
2. I feel bored	1	2	3	4	5
3. I dislike it	1	2	3	4	5
4. I find it pleasurable	1	2	3	4	5
5. It's no fun at all	1	2	3	4	5
6. It gives me energy	1	2	3	4	5
7. It makes me depressed	1	2	3	4	5
8. It's very pleasant	1	2	3	4	5
9. My body feels good	1	2	3	4	5
10. I get something out of it	1	2	3	4	5
11. It's very exciting	1	2	3	4	5
12. It frustrates me	1	2	3	4	5
13. It's not at all interesting	1	2	3	4	5
14. It gives me a strong feeling of success	1	2	3	4	5
15. It feels good	1	2	3	4	5
16. I feel as though I would rather be doing something else	1	2	3	4	5

Motl, R. W., Dishman, R. K., Saunders, P. U., Dowda, M., Felton, G., & Pate, R. (2001). Measuring enjoyment of physical activity in adolescent girls. American Journal of Preventive Medicine, 21, 110-117.

Study ID_____

Appendix 9. Teacher questionnaire

FOR OFFICE USE ONLY- P/ I.D.

Physical activity in the school environment

Your name: _____

Your school:_____

1. Does the school have:		
a. Useable outdoor basketball/netball courts	**Yes**	**No**
b. Playing fields as part of the school grounds	**Yes**	**No**
c. Playing fields in reasonable walking distance	**Yes**	**No**
d. Swimming facilities in the school grounds	**Yes**	**No**
e. Swimming facilities in reasonable walking distance	**Yes**	**No**
f. Tennis courts	**Yes**	**No**
g. Cricket nets	**Yes**	**No**
h. A weights room	**Yes**	**No**
i. An indoor playing space (e.g., school hall)	**Yes**	**No**
j. A bike or path near or around the school	**Yes**	**No**
k. A playground/quadrangle	**Yes**	**No**
l. A gymnasium	**Yes**	**No**
m. A fitness lab	**Yes**	**No**
n. Other	**Yes**	**No**

2. Are the following facilities available for physical activity during lunchtimes? (Please select the appropriate response for EACH facility)			
a. Useable outdoor basketball /netball courts	**N/A**	**Yes**	**No**
b. Playing fields	**N/A**	**Yes**	**No**
c. Tennis courts	**N/A**	**Yes**	**No**
d. Cricket nets	**N/A**	**Yes**	**No**
e. A weights room	**N/A**	**Yes**	**No**
f. Swimming facilities	**N/A**	**Yes**	**No**
g. Indoor playing area (e.g. school hall)	**N/A**	**Yes**	**No**
h. A playground/quadrangle	**N/A**	**Yes**	**No**
i. Gymnasium	**N/A**	**Yes**	**No**
j. A fitness lab	**N/A**	**Yes**	**No**
k. Other	**N/A**	**Yes**	**No**

3.	**Of the facilities that are available, how often are they used by students for physical activity during lunchtimes?** (Please select the appropriate response for EACH facility)						
a.	Useable outdoor basketball/netball courts playing fields	N/A	Rarely/ Never	Less than once a week	Once a week	2-3 days per week	4-5 days per week
b.	Tennis courts	N/A	Rarely/ Never	Less than once a week	Once a week	2-3 days per week	4-5 days per week
c.	Cricket nets	N/A	Rarely/ Never	Less than once a week	Once a week	2-3 days per week	4-5 days per week
d.	A weights room	N/A	Rarely/ Never	Less than once a week	Once a week	2-3 days per week	4-5 days per week
e.	Swimming facilities	N/A	Rarely/ Never	Less than once a week	Once a week	2-3 days per week	4-5 days per week
f.	Indoor playing space (e.g. school hall)	N/A	Rarely/ Never	Less than once a week	Once a week	2-3 days per week	4-5 days per week
g.	Playground /quadrangle	N/A	Rarely/ Never	Less than once a week	Once a week	2-3 days per week	4-5 days per week
h.	Gymnasium	N/A	Rarely/ Never	Less than once a week	Once a week	2-3 days per week	4-5 days per week
i.	A fitness lab	N/A	Rarely/ Never	Less than once a week	Once a week	2-3 days per week	4-5 days per week
j.	Other	N/A	Rarely/ Never	Less than once a week	Once a week	2-3 days per week	4-5 days per week

4. Are the following facilities available for students to use without supervision before/after school? (Please select the appropriate response for EACH facility)		Before School		After School	
a. Useable outdoor basketball/netball courts	N/A	Yes	No	Yes	No
b. Playing fields	N/A	Yes	No	Yes	No
c. Tennis courts	N/A	Yes	No	Yes	No
d. Cricket nets	N/A	Yes	No	Yes	No
e. A weights room	N/A	Yes	No	Yes	No
f. Swimming facilities	N/A	Yes	No	Yes	No
g. Indoor playing area (e.g. school hall)	N/A	Yes	No	Yes	No
h. School playground/quadrangle	N/A	Yes	No	Yes	No
i. Gymnasium	N/A	Yes	No	Yes	No
j. Other	N/A	Yes	No	Yes	No

5. Of the facilities that are available, how often are they used by students for physical activity <u>BEFORE</u> school? (Please select the appropriate response for <u>EACH</u> facility)

a.	Useable outdoor basketball/netball courts	N/A	Rarely / Never	Less than once a Week	Once a week	2-3 days per week	4-5 days per week
b.	Tennis courts	N/A	Rarely/ Never	Less than once a Week	Once a week	2-3 days per week	4-5 days per week
c.	Cricket nets	N/A	Rarely/ Never	Less than once a Week	Once a week	2-3 days per week	4-5 days per week
d.	A weights room	N/A	Rarely/ Never	Less than once a Week	Once a week	2-3 days per week	4-5 days per week
e.	Swimming facilities	N/A	Rarely/ Never	Less than once a Week	Once a week	2-3 days per week	4-5 days per week
f.	Indoor playing space (e.g. school hall)	N/A	Rarely/ Never	Less than once a Week	Once a week	2-3 days per week	4-5 days per week
g.	Playground /quadrangle	N/A	Rarely/ Never	Less than once a Week	Once a week	2-3 days per week	4-5 days per week
h.	Gymnasium	N/A	Rarely/ Never	Less than once a Week	Once a week	2-3 days per week	4-5 days per week
i.	A fitness lab	N/A	Rarely/ Never	Less than once a Week	Once a week	2-3 days per week	4-5 days per week
j.	Playing fields	N/A	Rarely/ Never	Less than once a Week	Once a week	2-3 days per week	4-5 days per week

6. Of the facilities that are available, how often are they used by students for physical activity <u>AFTER</u> school? (Please select the appropriate response for EACH facility)							
a. Useable outdoor basketball/netball courts	N/A	Rarely/ Never	Less than once a Week	Once a week	2-3 days per week	4-5 days per week
b. Tennis courts	N/A	Rarely/ Never	Less than once a Week	Once a week	2-3 days per week	4-5 days per week
c. Cricket nets	N/A	Rarely/ Never	Less than once a Week	Once a week	2-3 days per week	4-5 days per week
d. A weights room	N/A	Rarely/ Never	Less than once a Week	Once a week	2-3 days per week	4-5 days per week
e. Swimming facilities	N/A	Rarely/ Never	Less than once a Week	Once a week	2-3 days per week	4-5 days per week
f. Indoor playing space (e.g. school hall)	N/A	Rarely/ Never	Less than once a Week	Once a week	2-3 days per week	4-5 days per week
g. Playground /quadrangle	N/A	Rarely/ Never	Less than once a Week	Once a week	2-3 days per week	4-5 days per week
h. Gymnasium	N/A	Rarely/ Never	Less than once a Week	Once a week	2-3 days per week	4-5 days per week
i. A fitness lab	N/A	Rarely/ Never	Less than once a Week	Once a week	2-3 days per week	4-5 days per week
j. Playing fields	N/A	Rarely/ Never	Less than once a Week	Once a week	2-3 days per week	4-5 days per week

7. In your view, how adequate are the sports/PE <u>FACILITIES</u> in your school? (Please tick <u>ONE</u> box only)	Poor, in need of much improvement ☐	Fair, in need of some improvement ☐	Good, in need of little improvement ☐	Excellent ☐

8. In your view, how adequate are the sports/PE <u>EQUIPMENT</u> in your school? (Please tick <u>ONE</u> box only)	Poor, in need of much improvement ☐	Fair, in need of some improvement ☐	Good, in need of little improvement ☐	Excellent ☐

9. How much time is allocated for PE (excluding sport) each week (on average) for:

	Minutes	N/A
Year 2		
Year 4		
Year 6		
Year 8		
Year 10		

10. How much time is allocated for Sport (excluding PE) each week (on average) for:

	Minutes	N/A
Year 2		
Year 4		
Year 6		
Year 8		
Year 10		

11. Which activities are offered in your school for PE or Sport: (Please tick the appropriate box for each facility)	**PE**		**Sport**	
Aerobics (01)	Yes	No	Yes	No
Athletics (02)	Yes	No	Yes	No
Aussie Sports (03)	Yes	No	Yes	No
Australian Rules (04)	Yes	No	Yes	No
Baseball (05)	Yes	No	Yes	No
Basketball (06)	Yes	No	Yes	No
Bush walking (07)	Yes	No	Yes	No
Cricket (08)	Yes	No	Yes	No
Cross country (09)	Yes	No	Yes	No
Cycling (competitive) (10)	Yes	No	Yes	No
Cycling (recreational) (11)	Yes	No	Yes	No
Dance(12)	Yes	No	Yes	No
Golf (13)	Yes	No	Yes	No
Fundamental Movement Skills /	Yes	No	Yes	No
Gross Motor Programs (14)	Yes	No	Yes	No
Gymnastics (15)	Yes	No	Yes	No
Hockey (16)	Yes	No	Yes	No
Ice-skating (17)	Yes	No	Yes	No
Indoor cricket (18)	Yes	No	Yes	No
In line Hockey(19)	Yes	No	Yes	No
Martial arts (20)	Yes	No	Yes	No
Netball (21)	Yes	No	Yes	No
Rock-climbing (22)	Yes	No	Yes	No
Roller blading (skating) (23)	Yes	No	Yes	No
Rowing (24)	Yes	No	Yes	No
Rugby League (25)	Yes	No	Yes	No
RugbyUnion(26)	Yes	No	Yes	No
Running (27)	Yes	No	Yes	No
Sailing (28)	Yes	No	Yes	No
Soccer (29)	Yes	No	Yes	No
Softball (30)	Yes	No	Yes	No
Squash(31)	Yes	No	Yes	No

Surfing(32)	Yes	No	Yes	No
Swimming (33)	Yes	No	Yes	No
Tennis (34)	Yes	No	Yes	No
Touch football (35)	Yes	No	Yes	No
Volleyball (36)	Yes	No	Yes	No
Walking (37)	Yes	No	Yes	No
Waterpolo(38)	Yes	No	Yes	No

12. Does the school offer organised physical activities which are available to students:

(Please circle ONE box only per line)

Before School	N/A	Rarely/ Never	Less than once a week	Once a week	2-3 days per week	4-5 days per week
At Lunchtime	N/A	Rarely/ Never	Less than once a week	Once a week	2-3 days per week	4-5 days per week
After School	N/A	Rarely/ Never	Less than once/ Week	Once a week	2-3 days per week	4-5 days per week

13. Who generally teaches PHYSICAL EDUCATION in your school? (You can tick MORE THAN ONE box)

FOR PRIMARY SCHOOLS ONLY

Classroom teachers	☐
Specialist PE teachers	☐
Parents	☐
Outside sporting groups or external contractors	☐
RFF teachers	☐
Other (please specify)	☐

FOR SECONDARY SCHOOLS ONLY

PDHPE teachers only	☐
PDHPE staff plus a few teachers from other KLAs	☐
Teachers from a range of other faculties	☐
Parents	☐
Outside sporting groups or external contractors	☐
Other (please specify)	☐

14. Who generally teaches sport in your school? (You can tick MORE THAN ONE box)

Mostly specialist PE teachers	☐
Mostly classroom teachers (across all KLAs)	☐
Parents	☐
Outside sporting coaches or external contractors	☐

15. How strong is support for SPORT within your school generally? (Please tick ONE box only)

Poor, in need of much improvement	☐
Fair, in need of some improvement	☐
Good, in need of little improvement	☐
Excellent	☐

16. How strong is support for PE within your school generally? (Please tick ONE box only)	
Poor, in need of much improvement	□
Fair, in need of some improvement	□
Good, in need of little improvement	□
Excellent	□

17. How well are PE and sport generally supported by PARENTS at your school? (Please tick ONE box only)	
Poor, in need of much improvement	□
Fair, in need of some improvement	□
Good, in need of little improvement	□
Excellent	□

18. Below are some barriers to enhancing skill development, fitness, and physical activity in children and adolescents. Please show how strongly you think each one applies to your school.

(Please tick ONE box for each line)

	Does not apply	Applies a little	Applies a fair amount	Applies strongly	Applies Very strongly
Competing demands on curriculum time	□	□	□	□	□
Amount of equipment available	□	□	□	□	□
Expertise of teachers	□	□	□	□	□
Amount and standard of facilities	□	□	□	□	□
Lack of wet weather facilities	□	□	□	□	□
Level of school/ home/ community interaction	□	□	□	□	□

Motivation/attitude of members of staff	□	□	□	□	□
Absence of a quality PE or sport program	□	□	□	□	□
Lack of interest from students	□	□	□	□	□
The gender of students	□	□	□	□	□
Cultural background of students	□	□	□	□	□

19. Below is a list of approaches that schools can use to promote physical activity amongst their students. Please indicate what level they are at present in your school. (Please circle ONE response for each line)						
Encouraging walking or bicycling to school	I don't know	Never/ rarely	A little of the time	A fair amount of the time	Most of the time	Always
Encouraging parents to use facilities	I don't know	Never/ rarely	A little of the time	A fair amount of the time	Most of the time	Always
Encouraging students to be more active outside school	I don't know	Never/ rarely	A little of the time	A fair amount of the time	Most of the time	Always
Encouraging the use of equipment and facilities during school hours	I don't know	Never/ rarely	A little of the time	A fair amount of the time	Most of the time	Always
Encouraging the use of equipment and facilities before school	I don't know	Never/ rarely	A little of the time	A fair amount of the time	Most of the time	Always
Encouraging the use of equipment and facilities after school	I don't know	Never/ rarely	A little of the time	A fair amount of the time	Most of the time	Always
Encouraging staff members to be involved in lunchtime activity programs	I don't know	Never/ rarely	A little of the time	A fair amount of the time	Most of the time	Always

Remedial motor skills programs for students	I don't know	Never/ rarely	A little of the time	A fair amount of the time	Most of the time	Always
Peer support programs in physical activity	I don't know	Never/ rarely	A little of the time	A fair amount of the time	Most of the time	Always
Permitting community organisations to use facilities for physical activity outside school hours	I don't know	Never/ rarely	A little of the time	A fair amount of the time	Most of the time	Always
Involving students in decision making regarding the sports and physical activities they participate in and the use and maintenance of facilities and equipment	I don't know	Never/ rarely	A little of the time	A fair amount of the time	Most of the time	Always
Encouragement/merit award	I don't know	Never/ rarely	A little of the time	A fair amount of the time	Most of the time	Always

Appendix 10. Parent questionnaire

FOR OFFICE USE ONLY- P/ I.D.

Parent Questionnaire

Your name: _____

Your child's name: _____

Your child's identification number:_____

Your child's teacher: _____

School: _____

To protect your privacy this cover sheet will be removed and destroyed once you have been allocated a study number.

ABOUT YOU AND YOUR FAMILY

The following questions provide us with information about you and your family. These details will be treated in the strictest confidence.

Q 1 What is your sex? (please tick one)

- ❑1 Male
- ❑2 Female

Q 2 Where were you born? (please tick one)

❑1 Australia ❑2 Other (please state)_____

Q 3 In your household, do you usually speak English? (please tick one)

- ❑1 Yes
- ❑2 No

Q 4 What is your highest level of schooling? (please tick one)

- ❑1 Never attended school
- ❑2 Primary school
- ❑3 Some high school
- ❑4 Completed high school
- ❑5 Technical or trade school certificate/apprenticeship
- ❑6 University or tertiary qualification

The following questions are about the child you have named on the front cover of this questionnaire

Q 5 How many hours per night does your child usually sleep?

Write the number here:_____ hours

Q6 What relation are you to the child involved in this study? (Please tick one)

- ❑1 Mother
- ❑2 Father
- ❑3 Grandparent
- ❑4 Guardian
- ❑5 Other (please state) : _____

Play spaces – within the boundaries of your home and yard / garden

Please tell us about your yard.

Q 7 **We have:** (please tick <u>one</u>)

- ❑$_1$ No yard at all
- ❑$_2$ No private yard
- ❑$_3$ A small yard (eg. Unit)
- ❑$_4$ A medium yard (eg. Standard block of land)
- ❑$_5$ A large yard (eg. ¼ acre or more)

Q 8 **Which of the following do you have within or outside of your home/yard/ garden?** (please tick all that apply)

Outside:

- ❑$_1$ Front fence
- ❑$_2$ Swimming pool/spa
- ❑$_3$ Trampoline
- ❑$_4$ Cubby house
- ❑$_5$ Basketball ring
- ❑$_6$ Covered area outdoors (eg. Patio, decked area, garage)
- ❑$_7$ Paved area outdoors
- ❑$_8$ Sandpits/swings/play equipment
- ❑$_9$ Other (please state)

  1)_____

  2)_____

  3)_____

Inside:

- ❑$_{10}$ Indoor play areas (eg. Rumpus room, family room)
- ❑$_{11}$ Study/computer area

Recreational equipment

Q 9 How often does your child use the following <u>at home</u>?
(Please tick <u>one</u> box for each line)

	Don't have 1	**Never/ rarley 2**	**Less than once per week 3**	**1-2 times per week4**	**3-4 times per week5**	**5-6 times per week6**	**Daily 7**
Balls	☐	☐	☐	☐	☐	☐	☐
Bats/rackets	☐	☐	☐	☐	☐	☐	☐
Bikes	☐	☐	☐	☐	☐	☐	☐
Home gym equipment	☐	☐	☐	☐	☐	☐	☐
Rollerblades	☐	☐	☐	☐	☐	☐	☐
Skateboards	☐	☐	☐	☐	☐	☐	☐
Skipping rope	☐	☐	☐	☐	☐	☐	☐
Scooter	☐	☐	☐	☐	☐	☐	☐
Toys that encourage active play (eg. frisbees, water pistols, kites)	☐	☐	☐	☐	☐	☐	☐

Q 10 Does your child have a TV in his/her bedroom? (please tick <u>one</u>)

❑1 Yes
❑2 No

Your local community

Q 11 How much do you agree or disagree with the following statements?
(please tick one box for each line)

	Strongly agree 1	**Agree 2**	**Neither 3**	**Disagree 4**	**Strongly disagree 5**	**Don't know 6**
There is heavy traffic in our local streets	☐	☐	☐	☐	☐	☐
Stranger danger is a concern of mine	☐	☐	☐	☐	☐	☐
Road safety is a concern in our area	☐	☐	☐	☐	☐	☐
There are no lights/crossings for my child to use	☐	☐	☐	☐	☐	☐
It is too dark and cold in the winter time for my child to play outside	☐	☐	☐	☐	☐	☐
It is too hot in the summer time for my child to play outside	☐	☐	☐	☐	☐	☐
There are no adults at home during daylight hours after school to supervise my child in active play outside	☐	☐	☐	☐	☐	☐
My child would have to cross several roads to get to areas where he/she can play	☐	☐	☐	☐	☐	☐
There are few sporting venues within our local area	☐	☐	☐	☐	☐	☐
I don't have enough time to transport my child to activities	☐	☐	☐	☐	☐	☐
Public transport is limited in my area	☐	☐	☐	☐	☐	☐

Sport and home fitness equipment items are too expensive for my family to buy	☐	☐	☐	☐	☐	☐
Sports and club fees are too expensive for my family to pay	☐	☐	☐	☐	☐	☐
There are not many other children around for my child to play with	☐	☐	☐	☐	☐	☐

Your home and family

Q 12 How often do the following people <u>provide support</u> for your child's participation in physical activity? (eg. take him/her to training, provide money for participation, buy sports clothing/equipment) (please tick <u>one</u> box for each line)

	Don't know / doesn't apply 1	**Never** 2	**Less than once per week** 3	**1-2 times per week** 4	**3-4 times per week** 5	**5-6 times per week** 6	**Daily** 7
Father/male carer	☐	☐	☐	☐	☐	☐	☐
Mother/female carer	☐	☐	☐	☐	☐	☐	☐
Grandparents (think about the one who provides the most support)	☐	☐	☐	☐	☐	☐	☐
Other person: (please state) _____	☐	☐	☐	☐	☐	☐	☐

Q 13 How often do each of the following people <u>praise</u> your child for participating in physical activity? (eg. say positive things to him/her, seem happy that he/she does it) (please tick <u>one</u> box for each line)

	Don't know / doesn't apply 1	**Never** 2	**Less than once per week** 3	**1-2 times per week** 4	**3-4 times per week** 5	**5-6 times per week** 6	**Daily** 7
Father/male carer	☐	☐	☐	☐	☐	☐	☐
Mother/female carer	☐	☐	☐	☐	☐	☐	☐
Grandparents (think about the one who provides the most praise)	☐	☐	☐	☐	☐	☐	☐
Other person: (please state) _____	☐	☐	☐	☐	☐	☐	☐

Appendix 11. SCORES lesson observation form

SCORES Lesson Observation and Feedback

SCORES
Supporting Children's Outcomes using Rewards, Exercise and Skills

School:	Teacher:	Weather conditions:

Term:	Date:	Time:	Participating students:	Non-participating students:

Focus of lesson:

Was the teacher using the SCORES teaching resources (i.e. FMS activity cards)?	YES	NO

Adherence to lesson structure *(circle responses and provide comments)*

INTRODUCTION	i) Teacher reviews previous lesson	YES	NO
	ii) Teacher explains lesson focus	YES	NO
	Comments:		
WARM-UP	i) Teacher provides skill-specific warm-up	YES	NO
	ii) Lesson involves general movement-based warm-up	YES	NO
	iii) Warm-up includes dynamic and/or static stretching	YES	NO
	Comments:		
SKILL DEVELOPMENT	i) Teacher or student demonstrates the skill	YES	NO
	ii) Lesson involves skill exploration	YES	NO
	iii) Lesson involves guided discovery	YES	NO
	Comments:		
SKILL APPLICATION	i) Lesson involves modified games	YES	NO
	ii) Lesson involves full-sided games	YES	NO
	Comments		
CLOSURE	i) Lesson includes cool down	YES	NO
	ii) Teacher uses questioning to check for student understanding	YES	NO
	iii) Teacher reinforces key skill components	YES	NO
	Comments		

General comments:

Adherence to SAAFE teaching principles *(circle and provide comments)*		*(1 = Not at all true* to *5 = Very true)*				
SUPPORTIVE	**i) Teacher provides individual skill specific feedback**	**1**	**2**	**3**	**4**	**5**
	ii) Teacher provides feedback on student effort and involvement	**1**	**2**	**3**	**4**	**5**
	iii) Teacher promotes positive interactions between students	**1**	**2**	**3**	**4**	**5**
	Comments:					
ACTIVE	**i) Activities involve small-sided games or tabloids and children spend minimal time waiting for a turn**	**1**	**2**	**3**	**4**	**5**
	ii) Teacher monitors students' activity levels (visually or using pedometers)	**1**	**2**	**3**	**4**	**5**
	iii) Equipment is plentiful and developmentally appropriate	**1**	**2**	**3**	**4**	**5**
	iv) Transitions between activities are efficient	**1**	**2**	**3**	**4**	**5**
	Comments:					
AUTONOMOUS	**i) Some activities incorporate multiple challenge levels**	**1**	**2**	**3**	**4**	**5**
	ii) Students are given choices about the tasks and activities	**1**	**2**	**3**	**4**	**5**
	iii) Students are involved in the set-up and running of activities	**1**	**2**	**3**	**4**	**5**
	Comments:					
FAIR	**i) Teacher ensures that students are evenly matched in activities**	**1**	**2**	**3**	**4**	**5**
	ii) Teacher acknowledges and rewards good sportsmanship	**1**	**2**	**3**	**4**	**5**
	iii) If necessary, teacher modifies activities to maximise opportunities for success	**1**	**2**	**3**	**4**	**5**
	Comments:					
ENJOYABLE	**i) Lesson starts with an enjoyable activity and concludes with an enjoyable experience**	**1**	**2**	**3**	**4**	**5**
	ii) Activities are meaningful and not repetitive	**1**	**2**	**3**	**4**	**5**
	iii) Lessons involve a wide range of activities	**1**	**2**	**3**	**4**	**5**
	Comments:					
General comments:						