The Fit-4-Fun Study:
Promoting physical activity and physical fitness in primary school-aged children

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Statement of Originality

The 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:

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Statement of Authorship

I hereby certify that the work embodied in this thesis contains a series of published paper/s/scholarly work of which I am a joint author. I have included as part of the thesis a written statement, endorsed by my supervisors, attesting to my contribution to the joint publication/s/scholarly work.

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Statement of Contribution of Others

Co-author statement

I, Professor Philip Morgan, attest that Research Higher Degree candidate Narelle Eather contributed substantially in terms of study concept and design, data collection and analysis, and preparation of the following manuscripts.

Professor Philip, J. Morgan Date: 15/04/2013

I, Associate Professor David, R. Lubans, attest that Research Higher Degree candidate Narelle Eather contributed substantially in terms of study concept and design, data collection and analysis, and preparation of the following manuscripts.

Associate Professor David, R. Lubans Date: 15/04/2013

1. Eather, N., Morgan, P.J., Lubans, D.R., 2012. Feasibility and preliminary efficacy of the Fit-4-Fun intervention for improving physical fitness in a sample of primary school children: a pilot study. Physical Education & Sports Pedagogy, 18:4, 389–411. (IF 2.34).
2. Eather, N., Morgan, P.J., Lubans, D.R., 2011. Improving health-related fitness in children: The Fit-4-Fun randomized controlled trial study protocol. *BMC Public Health,* 11:902. (IF 2.08).
3. Eather, N., P.J. Morgan, and D.R. Lubans, Improving the fitness and physical activity levels of primary school children: Results of the Fit-4-Fun group randomized controlled trial. *Preventive Medicine*, 2013. 56(1): p. 12–19. (IF=3.2)
4. Eather, N., P.J. Morgan, and D.R. Lubans, Social support from teachers mediates physical activity behaviour change in children participating in the Fit-4-Fun intervention. *International Journal of Behavioural Nutrition and Physical Activity*, 2013. 10(68). (IF 3.58)

Disclosure of editing services

Professional editor, Dr. Guenter Plum from FunctionalEdit.com, provided proofreading services, according to the guidelines laid out in the university-endorsed national 'Guidelines for editing research theses'. Dr. Plum's editing services included fixing typographical, spelling and common grammatical errors; checking in-text references against list of references; checking numbering of tables and figures; and checking consistency in lay-out.

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Finally, I would like to thank my family for their endless support in all that I do.

My parents, David and Vivienne, have always encouraged me to work hard and aim high in all facets of my life;

My twin sister Megan, who is my best friend, has travelled with me on the highs and lows of this journey and helps me keep perspective;

My brother Dean, a fellow physical educator;

My husband Darryn who has suffered the most during the creation of this thesis and has taken the burden of my time commitments (study, work and sport) – and still supports all that I do; and

My two beautiful girls Chloe and Emily, who mean the world to me and give me the motivation to take on life's challenges each and every day.

Publications

The following peer reviewed publications and presentations have been produced as a result of the research conducted for this thesis. I am the lead author for all four primary papers and am co-author for the two secondary papers.

The four primary papers are presented sequentially and provide published details relating to the design, implementation, development and evaluation of the Fit-4-Fun program. The program was specifically developed to target areas of both public health and educational concern, as identified in the literature, and the findings presented in this thesis will contribute greatly to the limited literature regarding successful multi-component school-based physical activity and physical fitness education programs for primary school children.

Primary Publications

1. Eather, N., Morgan, P.J., Lubans, D.R., 2012. Feasibility and preliminary efficacy of the Fit-4-Fun intervention for improving physical fitness in a sample of primary school children: a pilot study. Physical Education & Sports Pedagogy, 18:4, 389–411. (IF 2.34).
2. Eather, N., Morgan, P.J., Lubans, D.R., 2011. Improving health-related fitness in children: The Fit-4-Fun randomized controlled trial study protocol. *BMC Public Health,* 11:902. (IF 2.08).
3. Eather, N., P.J. Morgan, and D.R. Lubans, Improving the fitness and physical activity levels of primary school children: Results of the Fit-4-Fun group randomized controlled trial. *Preventive Medicine*, 2012. 56(1): p. 12–19. (IF=3.2)
4. Eather, N., P.J. Morgan, and D.R. Lubans, Social support from teachers mediates physical activity behaviour change in children participating in the Fit-4-Fun intervention. *International Journal of Behavioural Nutrition and Physical Activity*, 2013. 10(68). (IF 3.58)

Secondary Publications

Two secondary papers have been included as appendices in this thesis. These papers directly relate to specific aspects of the Fit-4-Fun study (fitness testing and the health benefits of muscular fitness in children), and provide a unique contribution to the limited literature in these areas of research. My contribution to each of the papers has been outlined below.

1. Lubans, D.R., Morgan, P., Callister, R., Plotnikoff, R.C., Eather, N., Riley, N., Smith, C.J. Test-retest reliability of a battery of field-based health-related fitness measures for adolescents. *Journal of Sports Sciences,* 2011. 29(7): p. 685–93 (ERA=B IF 2.082).

My contribution to the above study involved conducting all physical fitness assessments and reviewing the manuscript at all stages of writing.

2. Smith, J.J., Eather, N., Morgan, P.J., Plotnikoff, R.C., Faigenbaum, A.D. and Lubans, D.R. (*In Press*). The health benefits of muscular fitness for children and adolescents: A systematic review and meta-analysis. *Sports Medicine*. (IF 5.1)

I am second author for the above systematic review and my contribution to this paper included: identifying and screening relevant articles, assessing articles for eligibility, assessing the risk of bias of each study, checking extracted data for accuracy, writing sections of the paper and reviewing the paper at all stages of writing / review.

Presentations – Refereed Conference Abstracts

1. Eather, N., Morgan, P.J, and Lubans, D. (2009) Rationale and intervention description of a health-related fitness program for primary school children. *Journal of Science and Medicine in Sport*, 12(6) supp, p. 120. Annual Conference of Physical Activity and Sport Medicine Australia, Brisbane 2009: Poster presentation.

2. Eather, N., Morgan, P.J, and Lubans, D. (2010) The Fit-4-Fun Program: A curriculum-based approach to promoting health-related fitness in primary school children*, Obesity Research and Clinical Practice*, Sydney, NSW (2010). Annual Conference of Australia and New Zealand Obesity Society, Sydney 2010: Short oral and poster presentation.

3. Eather, N., Morgan, P.J, and Lubans, D. (2011) The Fit-4-Fun Program: promoting fitness and health in primary school children, 2011 Annual Meeting of the International Society for Behavioural Nutrition and Physical Activity (ISBNPA) eProceedings, Melbourne, VIC (2011): Poster presentation.

4. Eather, N., Morgan, P.J, and Lubans, D.R (2012). Improving health-related fitness in children: The Fit-4-Fun randomized controlled trial be active 2012: 4th International Congress on Physical Activity and Public Health Australian Conference of Science and Medicine in Sport National Sports Injury Prevention Conference 31 October – 3 November 2012 Sydney Convention and Exhibition Centre, New South Wales, Australia, Sports Medicine Australia: Oral presentation.

5. Eather, N., Morgan, P.J, and Lubans, D.R (2014). Social support from teachers mediates physical activity behaviour change in children participating in the Fit-4-Fun intervention. AIESEP World Congress 2014, Auckland New Zealand 10–14th February, 2014 – Oral presentation.

List of Abbreviations

Abbreviation	Term
BC	body composition
BMI	body mass index
BMI-Z	body mass index Z score
CRF	cardiorespiratory fitness
CVD	cardiovascular disease
HRF	health-related fitness
MF	muscular fitness
MVPA	moderate-vigorous physical activity
NCD	non-communicable disease
NSW	New South Wales
PA	physical activity
PDHPE	Personal Development, Health and Physical Education
PE	physical education
RCT	randomized controlled trial
sd	standard deviation
VO_2Max.	maximum oxygen uptake
VPA	vigorous physical activity
WC	waist circumference
WHO	World Health Organization
20m SRT	20 metre Shuttle Run Test
SCT	Social Cognitive Theory
CMT	Competence Motivation Theory
HR	heart rate
PF	Physical fitness

Definitions

Term	Definition
Physical activity	Physical activity is defined as: '…any body movement produced by the skeletal muscles and resulting in a substantial increase over the resting energy expenditure (p.11)' [1], and includes four components: volume, intensity, frequency and type.
Cardiorespiratory fitness	Cardiorespiratory fitness is a direct indicator of an individual's physiological status and reflects the overall capacity of the cardiovascular and respiratory system [2].
Vigorous physical activity	Vigorous physical activity in children has been defined as expending more than 7 Metabolic Equivalents (METs), or a minimum of 7.5 kilo cal/min, or working at a minimum of 70% of maximum heart rate, or 70% of VO_2max (e.g., running, sprinting, jumping, skipping) [3].
Moderate intensity physical activity	Moderate intensity physical activity has been defined as expending 3–4 METs, or approximately 5–7.5 kilo cals per min, or exercising at 60–70% of maximum heart rate, or at 60% of VO_2max (e.g., swimming, cycling, brisk walking) [3].
Body Composition	Body composition is the body's relative amount of fat mass (e.g., adipose tissue, essential fats and non-essential fats) to fat-free mass (e.g., bone, water, muscle, and tissues) [4].
Muscular Fitness	Muscular strength and muscular endurance are health-related fitness components that are often combined and labelled 'muscular fitness'. Generally defined, muscular strength is the ability to generate maximal force with a muscle or group of muscles; whereas, muscular endurance is the ability to perform repeated contractions with a muscle or group of muscles [5].
Child	In this thesis the term child refers to individuals aged 5-12 years.
Adolescent	In this thesis the term adolescent refers to individuals aged 13-18 years.
Mediator	A variable acting as a mediating agent and accounts for the relation between the predictor and the criterion [6].

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Abstract

Physical fitness is an important predictor of physical and psychological health in children and adolescents, yet evidence confirms that a large proportion of children are unfit and do not participate in physical activity of sufficient volume and intensity to accrue the associated health benefits. Given that children's fitness levels also decline with age, there is an urgent need to develop and evaluate interventions that promote high intensity physical activity, that are appealing to children and adolescents and contribute to the development and maintenance of high levels of physical fitness.

Objective

The primary aim of this thesis was to evaluate an eight-week school-based physical fitness education intervention (Fit-4-Fun) for improving the physical activity and physical fitness levels of Grades 5 and 6 primary school children. The secondary aim of this thesis was to explore potential mediators of physical activity in the Fit-4-Fun program.

Methods

Study type and participants

1) In 2010, a pilot randomized controlled trial (RCT) with a three-month wait-list control group was conducted in two primary schools, in the Hunter Region, NSW, Australia. Children from Grades 5 and 6 were recruited for the studies (n = 49; mean age 10.9 years ± 0.7) and were randomized by school into the Fit-4-Fun intervention (n = 32) or the control (n = 17) conditions.

2) In 2011, a cluster RCT with a six-month wait-list control group was conducted in four primary schools in the Hunter Region, NSW, Australia. Children from Grades 5 and 6 were recruited for the studies (n = 213; mean age = 10.72 years ± 0.6) and were randomized by school into the Fit-4-Fun intervention (n = 118 students) or the control (n = 95) conditions.

Treatment conditions

The Fit-4-Fun intervention was a theoretically grounded eight-week physical fitness education program that included: 8 x 60 min Health and Physical Education (HPE) lessons (theory and practical – replacing the existing HPE program), a daily break-time activity program (recess and lunch) and a home fitness program. The control group participated in their usual weekly 60min health and physical education lesson.

Measures and statistical analysis

1) In the pilot study, assessments were taken at baseline and immediate post-intervention to determine changes in health-related fitness levels (cardiorespiratory fitness, muscular fitness, flexibility, and body composition), physical activity and changes in constructs from Social Cognitive Theory and Competence Motivation Theory. Intervention effects in the pilot study were assessed using analysis of covariance (ANCOVA).

2) In the cluster RCT, assessments were taken at baseline, immediate post-intervention and at six-months to determine changes in health-related fitness levels, physical activity and changes in constructs from Social Cognitive Theory and Competence Motivation Theory. Intervention effects were assessed using linear mixed models and mediation analysis was conducted using Preacher and Hayes' multiple mediation regression SPSS macro.

Process evaluation measures of recruitment, retention, adherence and satisfaction were also assessed in both trials to determine program feasibility.

Results

Pilot RCT: children in the intervention group improved in all health-related fitness measures with significant group x time effects (p <.05) observed in the seven-stage sit-up test (d = 0.9), the sit and reach tests (right leg d = 1.0, left leg d = 0.9, both legs d = 1.1) and the wall squat tests (right leg d = 0.9, left leg d = 0.6). No significant group x time effect was found in the beep test, basketball throw, physical activity measure or psychological measures. Process evaluation findings demonstrated high levels of recruitment, retention, adherence and satisfaction. Minor changes were made to the home activity program and program components based on feedback provided by participants and process evaluation results.

Cluster RCT: After six-months, significant treatment effects were found for cardiorespiratory fitness (20mSRT adjusted mean difference, 1.14 levels, 95% CI = 0.74 to 1.55 p < 0.001), body composition (BMI adjusted mean difference -0.96 kg/m^2, 95% CI = -1.42 to -0.5, p < 0.001 and BMI-Z adjusted mean difference -0.47 Z-scores, 95% CI = -0.70 to -.25, p < 0.001), flexibility (sit and reach adjusted mean difference 1.52cm, 95% CI = -0.65 to 3.68, p = 0.0013), muscular fitness (sit-ups) (adjusted mean difference 0.62 stages, 95% CI = -0.97 to -0.27, p = 0.003) and physical activity (mean, 3253 steps/day, 95% CI = 1776 to 4730, p < 0.001). There were no significant treatment effects for three of the muscular fitness measures.

Mediation Analysis: Teacher social support was found to have a significant mediating effect on physical activity in the cluster RCT (AB = 445, 95% CI = 77 to 1068 steps, proportion = 13%), and perceived school environment approached significance (AB = 434, 95% CI = -415 to 1507 steps, proportion = 13%). The targeted constructs of enjoyment, social support from parents and friends, and self-efficacy did not meet the criteria for mediation.

Process Evaluation: Measures of recruitment, retention, adherence and satisfaction were very high. In both trials all invited schools' principals and teachers agreed to participate in the Fit-4-Fun study.

1) In the pilot RCT, 85.7% of children invited to participate in the trial gained informed consent, all program sessions were delivered and 94% of participants were retained in follow-up assessments. Scores for the evaluation surveys ranged from 4.63 to 5.62 of a possible 6 for the 14 items in the evaluation survey, implying high-to-very high satisfaction rates for the Fit-4-Fun program.

2) In the cluster RCT, 93.8% of the 226 eligible participants completed all baseline assessments, 86.7% completed the 10-week follow-up measures and 90.7% completed the six-month assessments. All eight curriculum sessions were presented at the treatment schools with an attendance rate of 94% and mean scores for the evaluation survey categories ranged from 4.29 to 5.33 of a possible 6 for the 14 items in the evaluation survey – also indicating high to very high overall satisfaction rates for the Fit-4-Fun program.

In both trials, students reported difficulties with adhering to the home component which relied on parent/family involvement in the program with a mean score of 2.84 (pilot RCT) and 3.33 (cluster RCT) of a possible 6 for perceived parental and family involvement.

Conclusion

A multi-component, curriculum-based health-related fitness intervention for primary school children that targeted the three areas of a health promoting school and targeted teacher social support for participation in physical fitness activities is feasible and efficacious in improving health-related fitness and physical activity levels in children.

Overview

Fit-4-Fun study

The Fit-4-Fun program is a novel intervention purposely designed, implemented and evaluated as a PhD study. The program was specifically developed to target areas of both public health and educational concern, as identified in the literature. An outline of the contribution that I, Narelle Eather, made to the Fit-4-Fun study is outlined below.

Program design and development

I was responsible for the design and development of the entire Fit-4-Fun program. This included designing all program components (including program sessions, student and staff resources, and presentations), and amending specific program components for the RCT based on participant feedback and the results of the pilot study.

Ethics and safety approval

I was responsible for gaining ethics approval from the University of Newcastle and the Newcastle–Maitland Catholic Schools Office, for registering the trial with the Australian New Zealand Clinical Trial Registry (ACTRN12611000976987), and for completing all related safety and child protection procedures relating to the implementation of both trials in the primary school setting. This included: developing a study proposal and justification, completing all ethics forms, developing information statements and consent forms for teachers, parents, children and school Principals, developing assessment protocols and forms for all physical assessments, developing the student and staff questionnaires and evaluation surveys, and ensuring all mandated child protection checks were completed for research staff.

Measurement of study outcomes, data collection and entry

In correspondence with my supervisors, appropriate outcome measures were decided upon. I was wholly responsible for training more than 70 volunteer research assistants in conducting the physical fitness tests, organising assessment sessions (including ordering and organising all equipment and scheduling sessions in the school) and supervising research assistants during all assessment sessions. The research assistants recorded participants' results and I was responsible for entering the data onto the computer and for the safe handling of all confidential participant information.

Intervention delivery

I was entirely responsible for delivering all program sessions at all intervention schools in both the pilot and RCT of the Fit-4-Fun study. This included face-to-face delivery of the program sessions (56 sessions in total) and associated organisation of tasks and resources.

Analysis of data

In correspondence with my supervisors, the methods of statistical analysis were decided upon and I completed all analyses using appropriate computer software (SPSS and SAS Statistical Packages), interpreted the results and presented the data in either text, table or figure formats.

Acquiring funding

I was responsible for applying for grants related to the Fit-4-Fun study. This included two successful grants from Sports Medicine Australia and the Priority Research Centre in Physical Activity and Nutrition at the University of Newcastle.

Presenting study results at conferences

I was responsible for presenting the findings of the Fit-4-Fun study (both oral and / or poster presentations) at several conferences (local and international) and in the University Three-Minute Thesis competition (see page ix for full details).

Chapter One

Introduction

1.1 Background and Context

Physical activity and physical fitness are important markers of current and future health status [7-9]. Yet, studies have shown that many children across the globe are not meeting physical activity recommendations and do not display the levels of physical fitness required for achieving optimal health benefits [10]. Current trends in Australian indicate that only 25% of males and only 8% of females (5-17yrs) are meeting the recommended number of 12,000 steps/day [11], that over 30% of children do not meet recommended cardiorespiratory levels (measured by the 20 m SRT) and that health-related fitness levels in children and adolescents have declined over the last 20–30 years [12-21]. A common challenge identified by promoters of physical activity and physical fitness is how to engage children in physical activities and facilitate sustainable behaviour change [22, 23].

Recent studies have shown that children who participate in high levels of physical activity, especially vigorous activity, and display high levels of health-related physical fitness benefit both in the short- and long-term [9, 24, 25]. Active and fit children display fewer markers for Metabolic Syndrome, have a decreased risk of developing cardiovascular disease and are less likely to develop other chronic illnesses such as obesity, Type 2 diabetes mellitus, osteoporosis and some cancers [8]. They are also less likely to suffer from psychological disorders [26], and more likely to perform better academically [27]. Furthermore, evidence is mounting to support the view that markers of ill-health and physical fitness levels exhibited in childhood, track through to adolescence and adulthood, highlighting the need for the development of early interventions targeting the physical activity levels and physical fitness levels of children [9, 28].

In response to the declining physical activity and physical fitness levels of children, and the increase in non-communicable diseases (NCD) in developing and developed countries, the World Health Organization (WHO) published the *Global Recommendations on Physical Activity and Health* [29]. These recommendations now address the link between the frequency, duration, intensity, type and total amount of physical activity needed for preventing NCD [29]. The most recent WHO recommendations assert that children aged 6–17 years should participate in at least 60 minutes of moderate-to-vigorous (MVPA) physical activity every day, and to perform vigorous physical activity (high intensity), muscle-strengthening physical activities and bone-strengthening physical activities, on at least three days per week [29].

The school setting is considered to be a key environment for implementing physical activity interventions [30-32]. The school, via the curriculum, school ethos and school community, is an ideal setting for accessing and educating children and adolescents about the importance of physical activity, the value of achieving and/or maintaining health-related fitness standards and for building the skills necessary for long-term behaviour change [33, 34]. Consequently, helping schools to identify the facilitators of, and barriers to, physical activity participation in children and adolescents has become an area of interest for researchers – and a health priority [35]. There are numerous opportunities in the school setting for the promotion of physical activity and for expanding participation opportunities for children. Although health and physical education is widely acknowledged as the cornerstone of a school's physical activity program, studies have questioned the quality and quantity of health and physical education lessons delivered in primary schools and physical opportunities in the school setting have been under-utilized in the past [10, 36-39]. In support, the Australian Government Independent Sport Panel [39-41] has called for adequate teacher training, time and resources for the development of quality physical education in primary schools as a way of meeting educational outcomes, improving the nation's health, and affirming the importance of skill development and community sports participation. Consequently, there is a call for evidence-based approaches to be incorporated into primary school physical education programs to ensure a concentrated effort on public health concerns and educative outcomes [39].

The development of effective school-based physical activity interventions may be an important step in facilitating long-term behaviour change in children. However, it is important for physical activity interventions to be evidence-based and be founded on an established theoretical framework which helps to determine how an intervention worked and how future interventions can be improved [42, 43]. Social Cognitive Theory [44], Ecological Theory [45, 46], Competence Motivation Theory [47] and The Health Promoting School Model [48] are commonly used by physical activity researchers. When used collectively, they highlight critical social, behavioural and environmental factors influencing physical activity behaviours in children. By utilizing existing theoretical frameworks for facilitating behaviour change and operationalizing key constructs, researchers are able to address possible mediators of physical activity behaviour change in children (e.g., social support, self-efficacy, supportive environment, enjoyment) and maximize the potential intervention effects [44, 47]. Moreover, there is a growing need for the integration of theories to increase intervention effectiveness [49, 50], and given the limited number of studies investigating the mediators of physical activity behaviour change, especially in children, further research in this area is warranted.

The literature continues to build and provide support for the effectiveness of school-based physical activity interventions for improving various measures of physical activity and health [50, 51]. However, evidence for the effectiveness of interventions for improving objectively measured physical activity across a range of settings (i.e., school, home/family, community) has been mixed and it is not always clear whether the reviewed interventions were effective in the context in which they were delivered (e.g. class time, recess) or effective for increasing overall PA.Van Sluijs, Kriemler and McMinn (2011), Kamath et al. (2008) and Metcalf, Henley and Wilkins (2012) reviewed the effectiveness of physical activity interventions targeting children and adolescents across a range of settings (e.g., community and family settings), and found minimal effects on physical activity behaviours – with interventions in the home setting showing greatest potential [52-54]. Two recent systematic reviews by Kriemler et al. (2011) and Dobbins et al. (2013) reported that school-based interventions can be effective in improving physical activity behaviours and health-related fitness (especially cardiorespiratory fitness) in children [49, 50]. The authors also reported that multi-component, 'whole-school' approaches for promoting physical activity are the most effective, applicable and cost-effective investments for improving physical activity behaviours in children [30, 55, 56]. Unfortunately, the majority of studies included in these physical activity reviews were at a minimum, of moderate risk of bias (given the array of identified methodological shortfalls), many were limited by their exclusion of family involvement and out-of school program components, and the authors highlighted that the results must be interpreted with caution [49, 50, 54, 57-60]. Furthermore, the sustainability of many existing physical activity programs is questionable, given that the primary school teacher currently faces an over-crowded curriculum, where additional programs that do not align with mandatory curriculum requirements may be considered a time burden by classroom teachers.

1.2 Limitations of Existing School-Based Physical Activity Interventions

Although some studies have reported positive effects on physical activity outcomes, as well as some physical fitness outcomes, the potential impact of school-based interventions may have been hampered by their failure to:

1. Address the multiple components that influence behaviour in the school setting;
2. Make reference to behavioural learning theories;
3. Specifically target improvements in ALL of the health-related fitness components [50, 51]; or
4. Align physical activity programs with the existing curricula or educational objectives in the primary school setting.

1.3 Purpose of Study

The current study known as the Fit-4-Fun study provides an original contribution to the literature. No other study has investigated the feasibility and effectiveness of an innovative and engaging multi-component school-based physical fitness education program that directly aligns with the health and physical education curriculum, and targets improvements in both physical activity and all components of health-related physical fitness levels of primary school-aged children. The Fit-4-Fun program promotes and facilitates participation in 'enjoyable' physical activities in physical education, in the playground and at home, and is designed specifically to target areas of both public health and educational concern, as identified in the literature:

1. Inadequate physical activity levels of children [61-64];
2. Declining physical fitness levels of children [12-21];
3. Need for quality evidence-based physical education programs and resources to support teachers in primary schools [41, 65-70].

Furthermore, this study aims to identify the theoretical mediators of physical activity in children, adding to the limited literature in this area [57, 71].

1.4 Research Questions

Research Questions

1. What is the effect of a school-based intervention (Fit-4-Fun Program) on the health-related fitness and physical activity levels of primary school-aged children?

2. What are the potential mediators of intervention effects on children's physical activity (e.g., self-efficacy, enjoyment, supportive environment, social support)?
3. What is the feasibility of the Fit-4-Fun Program for improving physical activity and health-related fitness as a curriculum-based Health and Physical Education program in the primary school setting (using measures of adherence, retention, recruitment and satisfaction)?

1.5 Significance of Study

The Fit-4-Fun program is an innovative multi-component physical fitness education program that specifically targets improvements in physical activity and all elements of health-related fitness in primary school-aged children. The multi-faceted program extends learning beyond the classroom through its implementation of the Health Promoting Schools Framework, uses fun and engaging learning activities to motivate children to adopt healthy behaviours, and includes a theoretically driven, curriculum-based program based on the NSW PDHPE K-6 syllabus [72] and established theories of behaviour change [47, 73, 74]. Additionally, the Fit-4-Fun program aimed to promote the development and maintenance of positive physical activity and health-related fitness behaviours and attitudes among children, by identifying and addressing possible mediators of behaviour change (e.g., social support, self-efficacy, supportive environment, enjoyment) [47, 73, 74]. Importantly, the Fit-4-Fun program was designed to be incorporated into existing school structures (curriculum and time), without adding to the already over-crowded teaching program experienced by many primary school teachers [65, 75].

In response to methodological shortfalls identified in previous reviews of physical activity interventions [49, 50, 54, 57-60], the Fit-4-Fun program was evaluated using a rigorous study design. First, the Fit-4-Fun study adhered to the Consolidation Standards of Reporting Trials (CONSORT) guidelines [76]. Second, primary and secondary outcomes were measured by trained research assistants who were blinded to treatment allocation at baseline, all assessments being conducted using validated physiological and psychological assessments; additional steps were taken to minimize the risk of bias (e.g., use of intention-to-treat imputation for missing data, inclusion of treatment groups who display similar characteristics at baseline, and adequately powered to detect changes in primary outcome). Furthermore, detailed process evaluations were conducted and included measures of recruitment, retention, adherence and satisfaction to provide valuable evidence for future program refinement and implementation.

1.6 Thesis Structure

This thesis is presented as a collection of publications and presents four primary and two secondary peer reviewed publications accompanied by contextual chapters to provide overall structure. The thesis contains:

1. An overall abstract;
2. A summary of the main findings in each paper;
3. Eight chapters including:

a. A review of the literature;

b. Four published primary papers detailing the findings of the Fit-4-Fun study presented as individual chapters; and

c. A discussion and summary of all findings presented in the final chapter. This thesis provides a detailed presentation of the Fit-4-Fun study from conception, to implementation and evaluation.

Two secondary papers have been included as appendices to this thesis. These papers directly relate to specific aspects of the Fit-4-Fun study (fitness testing and the health benefits of muscular fitness in children), and provide a unique contribution to the limited literature in these areas of research.

The thesis chapters are as follows:

Chapter One: Introduction: Contextual information, a rationale for the implementation of the Fit-4-Fun study, and an outline of limitations evident in existing school-based physical activity intervention studies are provided in this chapter. Furthermore, details of the purpose and aims of the Fit-4-Fun study, and the significant contribution that this study will make to the literature, are also detailed in this chapter.

Chapter Two: Literature Review: This chapter discusses the rationale for promoting physical activity and physical fitness in children, and provides an overview of the associated health benefits. Current physical activity and physical fitness trends in children and adolescents are also summarized, along with recent physical activity recommendations for this age group.

Chapter Three: Literature Review: This chapter provides a review of the impact of recent school-based physical activity and physical fitness interventions and examines the relevant theoretical frameworks for understanding physical activity behaviours in children and adolescents.

Chapter Four: The results of the Fit-4-Fun pilot RCT and a description of the feasibility and preliminary efficacy of the Fit-4-Fun intervention for improving health-related fitness and increasing physical activity in primary school-aged children is presented in this chapter, previously published as: Eather, N., Morgan, P.J., Lubans, D.R., 2012. Feasibility and preliminary efficacy of the Fit-4-Fun intervention for improving physical fitness in a sample of primary school children: a pilot study. *Physical Education & Sports Pedagogy,* 18:4, 389–411. (IF 2.34)

Chapter Five: This chapter describes the rationale and methods of the Fit-4-Fun cluster randomized controlled trial for improving the physical fitness and physical activity levels of Grades 5 and 6 primary school children. This chapter was previously published as: Eather, N., Morgan, P.J., Lubans, D.R., 2011. Improving health-related fitness in children: The Fit-4-Fun randomized controlled trial study protocol. *BMC Public Health,* 11:902. (IF 2.08).

Chapter Six: The findings of the Fit-4-Fun cluster randomized controlled trial are presented in this chapter, previously published as: Eather, N., P.J. Morgan, and D.R. Lubans, Improving the fitness and physical activity levels of primary school children: Results of the Fit-4-Fun group randomized controlled trial. *Preventive Medicine*, 2012. 56(1): p. 12–19. (IF=3.2)

Chapter Seven: An investigation of potential mediators of physical activity change in the Fit-4-Fun study was conducted, and the findings of the mediation analysis are provided in this chapter, previously published as: Eather, N., P.J. Morgan, and D.R Lubans, Social support from teachers mediates physical activity behaviour change in children participating in the Fit-4-Fun intervention. *International Journal of Behavioural Nutrition and Physical Activity*, 2013. 10(68). (IF 3.58)

Chapter Eight: Discussion: In this chapter, an overview and synthesis of the key findings of the Fit-4-Fun study will be presented. Study significance and limitations are then presented, implications for professional practice, pre-service education and teacher training in schools, and recommendations for future research are discussed.

Chapter Two

The Importance of Physical Activity and Physical Fitness for Children

This chapter discusses the rationale for promoting physical activity and physical fitness in children, and provides an overview of the associated health benefits. The epidemiology of physical activity and physical fitness in both children and adolescents is also summarized, along with current recommendations and guidelines. Figure 2.1 summarizes the structure of Chapter Two.

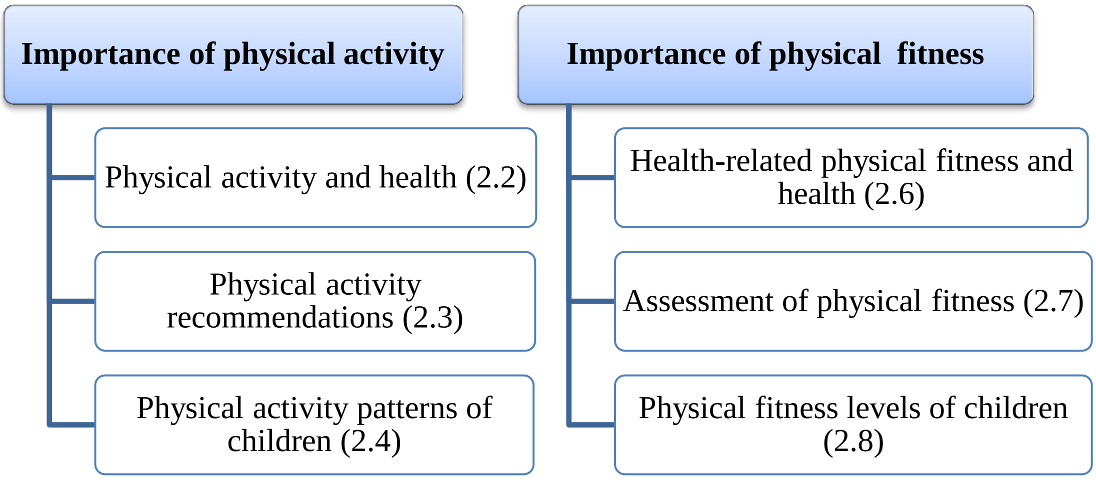

Figure 2.1: Structure of Chapter Two

2.1 Physical Activity and Health

Physiological Benefits – Overview

A strong and expanding body of evidence, drawing upon both observational and experimental studies, confirms the important role of regular physical activity in the primary and secondary prevention of several chronic diseases and premature death in the general population [77, 78]. In 2005, a systematic review demonstrated the association between physical activity and several health and behavioural outcomes in school-aged children and adolescents [79]. The authors reported adequate-to-strong evidence for the beneficial effect that physical activity has on adiposity, musculoskeletal health and fitness, several components of cardiovascular health (including blood pressure, plasma lipid and lipoproteins levels, inflammatory markers, endothelial function and heart rate variability) and on several components of mental health (self-concept, anxiety and depression) [79]. An updated systematic review in 2010 by Janssen and LeBlanc of the benefits of physical activity and fitness in school-aged children, strengthened the evidence for these conclusions and reported that the dose-response relations observed in observational studies indicate that the more physical activity undertaken, the greater the health benefit [3]. Additionally, recent reviews have indicated that vigorous or high intensity physical activity provide the greatest health benefits for all ages – especially children [3, 80-82]. Given that some studies have found that high levels of physical activity in childhood track through to adolescence [83], and significantly predict a high level of physical activity during adulthood [84], evidence-based strategies are needed to increase the quantity and intensity of physical activity undertaken by children.

Physical Activity and Cardiovascular Health

Participation in regular physical activity has been shown to provide indirect protection against coronary heart disease through its influence on other risk factors in adults, including: high blood pressure, high cholesterol and diabetes mellitus [85-88]. Recent studies have now also strongly linked physical activity (especially MVPA) with several components of cardiovascular health, and cardio-metabolic risk in children and adolescents [79, 87, 89-96]. Moreover, it has been recognized that cardiovascular disease is partly a paediatric problem, and that the onset of cardiovascular disease often lies in early childhood (in children as young as five), even though the clinical symptoms of this disease may not become apparent until adulthood [97, 98]. Furthermore, the clustering of cardiovascular disease and metabolic risk factors, such as abdominal obesity, high blood pressure, insulin resistance, elevated triglycerides, and lowered high-density lipoprotein cholesterol (HDL-c), has been observed in children and adolescents [99].

Physical Activity and Skeletal Health

Cross-sectional studies show that during late childhood and early adolescence the skeleton undergoes profound changes in bone mineral content and bone mineral density, with approximately 26% of total adult bone mass gained during this period (around 12.5 years of age for girls and 14.1 years of age for boys) [79, 100, 101]. This rate of bone mass accrual and the ‘peak bone mass’ achieved is directly related to physical activity [102, 103], and has been shown to track into early adulthood [104]. The emerging data suggested that increased mechanical load using dynamic, vigorous, weight bearing physical activities of short duration, are most effective for skeletal health – especially for children and adolescents [105-108]. This ‘window of opportunity’ for developing peak bone health is directly linked to the entire amount of bone mineral lost between the ages of 50–80 years – contributing to the development of bone disorders such as osteoporosis and fractures [101, 107, 109].

Physical Activity and Psychological Well-being

Mental illness is a serious public health issue [110, 111]. It has been estimated that 10%–20% of children and adolescents have psychological and behavioural problems, and in Australia, the mental health of children and adolescents appears to be worsening [112]. Participation in physical activity may have a positive impact on mental health [113, 114], especially in relation to psychosocial outcomes [64, 79, 114-120], depression and anxiety [114, 121-131], cognitive functioning [79, 114, 120, 132-139] and enhanced academic achievement [140]. The literature also suggests that participation in physical activities during childhood (e.g., sports, physical education) has preventative qualities in reducing the incidence of behavioural problems such as delinquency, aggression, and substance use [129, 141-145].

2.2 Physical Activity Recommendations

Physical activity recommendations for children and adolescents generally focus on the volume, frequency and intensity of physical activity, and have varied over time and across countries. In 1988, it was proposed that children and adolescents should participate in 20 to 30 minutes of vigorous exercise each day [146]. In 1998, the Health Education Authority symposium 'Young and Active?' proposed alternate physical activity recommendations for children and adolescents [147]. Their primary recommendation was that all children and adolescents should participate in physical activity of at least moderate intensity for one hour per day [147]. In 2010, after two systematic reviews of the literature examining the associations between physical activity and key fitness and health outcomes within school-aged children and adolescents [3, 148], new recommendations were made based on the dose-response relationship of physical activity and health and fitness outcomes. Current U.S., Australian and UK guidelines now encourage children and adolescents to participate in [149-152]:

- Moderate-vigorous physical activity (MVPA) for at least 60 min per day;
- Vigorous intensity physical activity (VPA) at least three times per week;
- Muscle and bone strengthening physical activities at least three times per week.

A review of objectively measured step data by Tudor-Locke and associates (2011), equated these guidelines with evidence-based recommendations for children and adolescents [153].

These researchers concluded that based on sex and age, boys aged six to 11 years should accumulate 13,000 to 15,000 steps per day, girls aged six to 11 years should accumulate 11,000 to 12,000 steps per day, and adolescents aged 12 to 19 years should accumulate 10,000 to 11,700 steps per day [153].

2.3 Physical Activity Patterns of Children and Measurement Issues

The accurate measurement of physical activity and physical fitness is vital to the epidemiological study of the association between physical activity and health, and of physical fitness and health [154]. However, making comparisons across time, countries and groups is difficult given that physical activity can be measured using a variety of instruments. These instruments can be grouped into categories and often include: calorimetry, job classification, survey procedures, physiological markers, behavioural observation, mechanical and electronic monitors [155-157]. The choice of a measurement instrument depends on the purpose of the evaluation, the nature and size of the study population, and the resources available [158]. Questionnaires (self-report measure) are considered to be the most feasible method of assessing physical activity patterns in large populations and represents the best compromise between acceptability and accuracy [154]. However, questionnaires are limited by reliability, sensitivity and validity ratings, and have been criticised for their inability to provide an accurate assessment of physical activity type, intensity, frequency, and duration, and the environment in which it is performed [154]. Objective measures of physical activity such as the use of calorimetry and doubly labelled water procedures have shown to be more accurate but are very costly [157, 159]. Consequently, pedometers and accelerometers have been used increasingly for smaller samples, as they have proven to provide a relatively accurate assessment of physical activity at a lower cost than laboratory-based methods [158, 160]. A review investigating the validity, reliability and feasibility of pedometer use with children was conducted by McNamara et al. (2010) and the authors concluded that pedometers correlated highly in terms of both criterion (direct observation) and convergent validity (heart-rate monitor, accelerometer), they had consistently high intra- and inter-unit reliability, and that pedometers were highly feasible for use in large-scale epidemiological studies due to their ease of use and low cost [161]. However, studies reporting compliance, reactivity and dealing with missing data using pedometry with children is limited, and given that issues with reactivity and tampering have shown to be evident in adolescents studies [162], standardized pedometer monitoring protocols are needed. Additionally, pedometers only detect ambulatory activity (and not activities such as resistance training or flexibility training) and therefore true intervention effects might not be captured during specific activities – making accelerometer the better alternative.

Comparing the effectiveness of physical activity interventions for children and adolescents is also problematic, as students' physical activity is often defined differently across studies (e.g., time spent in MVPA or step count), is measured using different assessment tools (e.g., self-report questionnaire, accelerometer, pedometer, observational tools) and is measured in different settings (e.g., school-based physical activity, sports, active transportation, after-school, physical education) [57]. Given the above information, difficulties have arisen when comparing data across time, groups, and countries due to the lack of consistency and standardisation of measurement [163]. However, the evidence uniformly supports that habitual physical activity levels among children (and adolescents) in not only developed countries, but worldwide, are inadequate and do not meet the minimum requirements recommended for good health [61-64], reinforcing the need for health promotion specifically targeting the physical activity behaviours of children and adolescents.

Global Physical Activity Trends

There is considerable disparity in the proportion of children and adolescents who meet national physical activity recommendations in developed countries (refer to Table 2.1). It is worth noting however, that cultural understanding of physical activity may determine national estimates of meeting physical activity guidelines and that the types of measure used for assessing physical activity levels will also influence compliance with national guidelines. Published statistics range from 8% in the Philippines and Zambia to 57% in Ireland, and from 12% in France to 50% in the United States [61, 164, 165]. In Australia, 46.5% of young children (Kindergarten to Grade 4) were reported by parents as spending 60 minutes or more per day in physical activity, with boys (50.5%) more likely than girls (42.2%) to meet the recommendations [166]. Self-report data from the 2010 School Physical Activity and Nutrition Survey (SPANS) indicates that in summer school terms, 62.7% of older Australian children and adolescents (Grade 6 to Grade 10) met the 60 min/day activity of the MVPA guidelines. In winter school terms, the corresponding proportion was 51.3% [166].

Similarly, pedometer data supports a large disparity in physical activity trends across nations, and highlights the difficulty in reporting physical activity trends given that many studies have methodological limitations (including small sample size, large age range, and selected populations) [167]. However, trends indicate that in Australia approximately 61–70% of 5 to 16 year-olds, and in the US, approximately 55–75% of 11 to 18 year-olds, do not meet the recommended number of steps/day [168-170]. Interestingly, data in most countries and regions indicate that more boys than girls meet the current guidelines, and that physical activity in children declines with age [20, 164, 170-177]. Table 2.1 below displays the latest available physical activity data for children and adolescents across the globe.

Table 2.1: Proportion of children and adolescents meeting physical activity recommendations

Country / Region	Time	Sample	N	PA Measure	PA Guideline	% Meeting Guidelines
Australia [171]	2010	5–16yrs: a) K, 2, 4 b) 6, 8, 10	8058	Questionnaire	60 min MPA/day	a) 46.5 b) 62.7
Germany [178]	2003–6	4–17yrs	4429	Questionnaire	60 min MPA/day	15.3
Canada [179, 180]	2007–9	6–19yrs	1608	Accelerometer	60 min MPA/day	7
Czech Republic [181]	2008–10	14–18yrs	1479	Pedometer	11,000 steps/day ♂ 9000 steps/day ♀	55-75
USA [182]	2011	11–18yrs	15,425	Questionnaire	60 min MPA/7days	29
UK [183]	2012	10–15yrs	629K	Questionnaire	VPA 3 + days/week	64 ♀ 70 ♂
New Zealand [184]	2007	12–18yrs	9107	Questionnaire	60 min PA/day	11
Poland [185]	2002	11–15yrs	6293	Questionnaire	60 min MPA/5days	35
Belgium [186]	2004	11–15yrs	10,612	Questionnaire	60 min MPA/5days	26
China [187]	2006–7	13–18yrs	32,005	Questionnaire	60 min MPA/5days	64 ♂ 40 ♀
34 countries [61]	2003–7	13–15yrs (5 WHO regions)	72,845	Questionnaire	60 min MPA/5days	23.8 ♂ 15.4 ♀
Saudi Arabia [188]	2009–10	14–19yrs	2908	Questionnaire	60min MVPA/day	43.5 ♂ 12.9 ♀

PA = physical activity MPA = moderate physical activity MVPA = moderate-vigorous physical activity

♂= boys/male ♀= girls/female

Physical Activity Patterns across the Day

There is limited data describing physical activity patterns across the day and across the week for children. Pedometer data from Grade 5 Canadian children collected by Van der Ploeg et al. (2014) and supported by data relating to 7–11 year old British children by Flardma, Home and Rowlands (2009), indicates that average daily step counts are higher on school days (boys 13,476 ± 4123 steps/day; girls 11,436 ± 3158 steps/day) than non-school days (boys 11,009 ± 5542 steps/day; girls 10,256 ± 5206 steps/day), and that more steps are taken during school hours than non-school hours [169, 189, 190]. Furthermore, Fairclough, Butcher and Stratton (2007) suggested that physical activity behaviours were more consistent in the school environment, with greater reliability in physical activity levels found between the hours of 7am and 3pm on school days [191]. A study conducted in New Zealand by Cox et al. (2006), reported contradictory data, indicating that primary school children performed slightly more physical activity out of school, with steps taken out of school making up 52.4% of total daily steps [192]. Additionally, Brusseau et al. (2011) found that boys took significantly more steps each day than girls during most physical activity opportunities during the day, including recess, lunch, after school, during the school day, and total day, but that boys and girls accumulated a similar number of steps during physical education [169]. This study also showed that lunchtime represented the largest source of physical activity for boys, followed by physical education and recess, but for girls, physical education was the most critical period for physical activity, followed by lunchtime and recess [169]. Furthermore, an Australian study conducted by Telford et al. (2009) found that pedometer-assessed physical activity in children (aged 8–11yrs) increased from Monday through to Friday, decreasing on Saturday and again on Sunday, and that physical activity was greater with boys, but less so at the weekend [193].

Physical Activity Patterns during School Breaks (recess / lunch)

Break times during the school day (recess and lunch) provide children with opportunities to engage in a range of physical activities and to develop physical fitness [194, 195]. Recess and lunch breaks have been shown to perform a critical role in schools, both as a necessary break from the rigors of academic tasks and as a complement to physical education [194, 196, 197]. There has been much debate around the topic of recess and how to best utilize this time to benefit the ‘whole’ child. Some researchers have argued for a more structured recess experience for children to ensure that all students are participating in MVPA that will contribute to their physical activity and physical fitness levels [198-200]. Others have argued that recess should remain a supervised, but unstructured break for children, where they have the opportunity to select between sedentary, physical, creative, or social activities [132, 196, 201-203].

In England, Ridgers et al. (2011) have studied the physical activity patterns of children during school breaks and reported that children are highly physically active during school breaks, and that on average, children engage in MVPA for at least half of their recess and lunch breaks [204]. However, this data varies greatly across countries [195]. These patterns of physical activity or 'free play' typically seen in the school day, accumulate and contribute up to 40–50% of total daily physical activity for children and adolescents [197, 205], potentially influencing their health and well-being [196, 206, 207]. Studies have also shown that boys often engage in more MVPA than girls during recess and lunchtime [208-211], and that differences between age groups and grades are often inconsistent [209, 212]. The intensity of children's physical activity decreases in both primary school and secondary school children over time (particularly during the transition from primary to secondary school), and that the contribution of recess and lunchtime to older children's daily physical activity also decreases [213, 214].

2.4 Summary

Despite considerable variability in study designs, recruitment, sampling, and testing methodologies, the data consistently shows that only 30–40% of children and adolescents are sufficiently active based on recent physical activity guidelines. Based on Australian data, on average children need to be performing at least 20min more MVPA or 3,000 more steps per day to meet current physical activity guidelines [215]. This trend towards physical inactivity is a global public health issue and recommendations for increasing the intensity volume, intensity, and frequency have been made [3, 64, 179]. Although there is inconclusive evidence as to whether physical activity levels have declined in recent decades, it is suggested that the majority of children and adolescents need to make changes to their routine physical activity patterns, and that various opportunities for increasing physical activity participation be explored (e.g., recess and lunch breaks, physical education, school and community sport, after-school active play, weekends, homework, active transportation) [64, 179, 216].

2.5 Rationale for Promoting Physical Fitness in Children

Defining Physical Fitness

Physical fitness can be defined as the capacity to perform physical activity and is determined by both genetics and participation in physical activity [217]. For most individuals, changes in the frequency, intensity, duration or type of physical activity produces changes in physical fitness (although the amount of adaptation in fitness varies) [218]. The fitness components that have been shown to directly relate to improvements in health are cardiorespiratory fitness (CRF), flexibility, muscular strength, muscular endurance and body composition – referred to as the health-related fitness (HRF) components [9, 24, 155, 219] (Figure2.2).

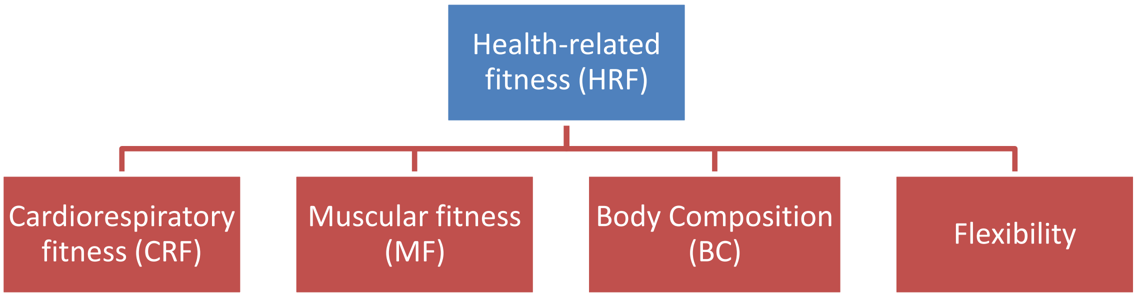

Figure 2.2: Health-related fitness components

2.6 Health-Related Physical Fitness and Health

Physiological Benefits – Overview

Current data confirms that high levels of health-related physical fitness (especially CRF, muscular fitness and body composition) in children and adolescents are associated with improved physical and mental health [82]. Recent studies have shown that children who display high levels of physical fitness present fewer markers of Metabolic Syndrome and have a decreased risk of developing cardiovascular disease – along with other chronic illnesses such as obesity, Type 2 diabetes mellitus, osteoporosis and some cancers [9, 82, 88, 95, 220-222]. These children are also less likely to suffer from anxiety and depression [223], and more likely to perform better academically [27, 224]. Emerging evidence has also confirmed that physical fitness is more strongly associated with health outcomes than accumulated physical activity [77, 88, 218, 225-231], and that vigorous physical activity (rather than total physical activity) is more important in the prevention of obesity [80, 82, 221, 229, 232]. It is unclear as to whether the increased benefits associated with vigorous physical activity rather than moderate and lower-intensity activities are attributed to the intensity of the activity or merely to the difference in energy expenditure, but the evidence consistently reports a larger reduction in mortality per increment of time of physical activity per week for vigorous-intensity exercise and sports than lower intensity activity [80]. Furthermore, fitness levels have been shown to track moderately well from childhood to adolescence, while physical activity shows somewhat weaker stability [84, 233-235]. Despite limitations attributed to the measurement of physical activity, these patterns imply that a focus on improving physical fitness in childhood may be a more promising health promotion strategy.

Cardiorespiratory / Aerobic Fitness and Health

Evidence confirms that vigorous physical activity (rather than moderate or total physical activity) is most important for improving cardiorespiratory fitness (CRF) in children and adolescents [3, 236-239]. CRF (maximum oxygen uptake, VO_2max.), is an important marker for health and disease in adults, and is the most researched component of fitness. It has been shown to be a strong predictor for a variety of non-communicable diseases and all-cause mortality [240]. Low levels of CRF in children and adolescents have also been associated with an elevated composite risk factor score for developing cardiovascular disease, for increased risk of clustering risk factors to persist into adulthood, and an increased predisposition for developing Metabolic Syndrome in both young boys and girls [9, 93, 222, 241-251] – whereas objectively measured physical activity has not been found to be associated with clustered risk [242, 246]. Furthermore, pre-pubertal boys and girls with low levels of CRF have been shown to display higher levels of certain non-traditional markers for metabolic syndrome such as uric acid and C-reactive protein [252, 253], more likely to be depressed [254, 255] and score poorly on measures of life satisfaction [256], academic performance [224, 257], and body image [258].

Body Composition and Health

Individuals with an excessive accumulation of body fat may be considered overweight or obese – and this has an array of negative health implications [259]. Furthermore, evidence consistently shows that overweight and obese children are more likely to display high levels of adiposity in adolescence and adulthood [248, 253, 260-263].

Body composition is a determinant of metabolic health [244, 251] and paediatric obesity is a growing and global public health threat. The prevalence of excess weight and obesity is reaching epidemic proportions in many developed and developing countries [264-268], with approximately 35% of US school-aged children in 2008 [267] identified as overweight (body mass index [BMI; kg/m2]: > 85th percentile) or obese (> 95th percentile) [267]. Similar rates of excess weight and obesity have been reported in the UK, Europe and in Asia, but lower levels are evident in Australia (22.8%) [166]. Several observational studies in child populations [269-272] have reported that obesity rates have increased while fitness levels have fallen, and others have shown inverse cross-sectional associations between various measures of fitness and adiposity [166, 273-277].

Obesity in childhood has both immediate and long-term psychological, physiological, and economic consequences [278]. Children who display high levels of adiposity often exhibit adverse physiological outcomes, such as: a heightened risk of developing cardiovascular risk factor clustering (including dyslipidemia, hypertension and fasting insulin levels), of developing metabolic syndrome and early inflammatory processes [279, 280], Type 2 diabetes, some forms of cancer [248, 253, 260-263], asthma [278] and orthopaedic disorders [281]. Measures of body composition (e.g., body mass index, body fat percentage) in children and adolescents are also inversely associated with psychosocial outcomes, such as: poor self-image and body satisfaction [242, 258, 282], sleep apnoea [278], perceived health status [256], self-esteem [283], depression [255, 284-288], life satisfaction, quality of family relationships, and academic performance [224, 256]. Weight status is also associated with the negative consequences that come with stigmatisation and teasing by peers [289-291].

Physical activity and physical fitness have an important role to play in the prevention of excess weight and obesity in children and adolescents. Overweight schoolchildren who achieve or maintain physical fitness are more likely to achieve a healthy weight, and healthy-weight children who maintain fitness are more likely to maintain a healthy weight (and protect them from becoming overweight or obese) [292]. However, studies have suggested that excess weight and obesity are limiting factors for fitness performance in primary school children and those overweight and obese children and adolescents are less fit than their leaner peers [9, 166, 250, 293-297].

Of recent interest, is data demonstrating that body fat in pre-school children (measured by BMI) is inversely associated with fitness in adolescence, independent of adolescent leisure time physical activity [298]. However, one study showed that young children who had a high pre-school BMI score, but reduced their weight status and/or increased their physical activity levels between the ages of nine and 17 years were able to achieve fitness levels equal to their leaner peers. This highlights that, not only is it important to maintain a healthy body weight and be physically active from early childhood through adolescence [298], but that interventions to reduce body fat and fitness in childhood may enable overweight children to reach high levels of fitness, irrespective of previous weight status. Moreover, the data suggests that interventions promoting children's health should, ideally, begin early in life and involve measures that simultaneously improve fitness and lower fatness[298] [297, 299].

Muscular Fitness and Health

Muscular fitness is emerging as an important marker of health across all ages, and has a threshold effect which is directly linked to all-cause mortality [9, 253, 300-302]. The inclusion of regular 'muscle and bone strengthening' physical activity recommendations in recent US physical activity guidelines, and now Australian physical guidelines for children and adolescents, demonstrates the importance of muscular fitness for population health [3, 152, 303].

Data is now showing that high levels of muscular fitness are associated with a healthier cardiovascular profile in childhood and adolescence [9, 304]. Cross-sectional studies involving children and adolescents have also shown that muscular fitness is inversely associated with clustered metabolic risk and cardiovascular disease risk, and is strongly associated with insulin sensitivity and bone mass accrual during this time [9, 88, 251, 302, 304-307]. In one study, muscular fitness presented a slightly stronger association with clustered metabolic risk compared to CRF in adolescents [251]. Moreover, longitudinal studies have shown that changes in muscular fitness from childhood to adolescence are associated with changes in overall and central adiposity, systolic blood pressure, blood lipids, and lipoproteins [253].

Although limited, studies have shown that muscular fitness is also associated with psychological and mental health. Children and adolescents with low muscular fitness report lower levels of perceived health status, life satisfaction, quality of family relationships, self-esteem and academic performance, in comparison to students who displayed high levels of muscular fitness [251, 308]. A study by Du Toit, Pienaar and Truter (2011) showed strong associations between several measures of fitness and academic performance in 9–12 year-olds, with the strongest associations between 12 year old boys and girls muscular fitness and academic achievement [224]. In other studies, low muscular fitness was also linked to high levels of smoking and alcohol use, and higher rates of depression, suggesting a link between muscular fitness and psychological health and health risk behaviour indicators in children and adolescents [302, 308].

2.7 Assessment of Fitness Levels

It is important that school-based interventions use valid and reliable measures of health-related physical fitness that are suitable for use in the school setting. There are, some concerns about the reliability and validity of results from field measures of fitness, however, field-based tests provide an alternative to laboratory test since they are time efficient, cheaper, require fewer resources and the tests can accommodate for multiple participants at once – ideal for the school setting [309]. Many factors influence children's performance on fitness tests and these may include: the environment or test conditions, lifestyle or previous experience with physical activity or fitness testing, testing protocols, participant's motivation, mechanical skill at taking the test, genetic potential, growth and maturation [310-312]. Given that there are over fifteen battery tests for the assessment of physical fitness in children and adolescents currently in use across the world [313], Castro-Piñero and associates (2010) conducted a systematic review of the criterion-related validity of commonly used field-based fitness tests. The authors reported strong evidence for the 20 m shuttle run test as a valid measure to estimate cardiorespiratory fitness, good evidence for the body mass index as an estimate of body composition, and reported moderate validity for the back saver sit and reach test to measure hamstring flexibility and lumbar flexibility [309]. Following on from this review, Ruiz and colleagues (2011) assessed the criterion validity and reliability of a range of field based tests in developing the ALPHA test battery, and reported that the 20mSRT, the standing broad jump and BMI can be considered both valid and reliable to assess cardiorespiratory fitness, musculoskeletal fitness and estimate of body fat, respectively [314]. Furthermore, these specific tests were shown to be feasible and safe for use in the school-setting given that they are relatively simple to administer using standardised protocols (minimising administrative errors), and require minimal equipment and time. In contrast, Castro-Piñero and associates (2010) found limited evidence for the reliability of a large number of other field-based fitness tests (especially tests of muscular fitness), primarily due to a limited number of studies. Difficulties in measuring the validity of muscular fitness tests arise due to the specificity of the type of muscular work performed and the use of different energy systems in performing selected tests. Furthermore, tests of muscular fitness have also been shown to be negatively influenced by body fat and body weight in children and therefore, do not always provide a true indication of fitness (e.g., pull up test, hang test, push up test and vertical jump) [309].

Several assessment tools have been developed and used for the measurement and comparison of physical fitness. However, even large scale testing batteries like the EUROFIT [315], the FITNESSGRAM [316], and the Australian Council for Health, Physical Education and Recreation ACHPER Australian Fitness Education Award [317], do not assess all of the components of physical fitness, nor do they promote a uniform set of health-related fitness standards for use with children and adolescents. Furthermore, an internationally accepted, reliable standard tool for the assessment of physical fitness in children and adolescents has not been agreed upon, making comparisons over time, and between countries and groups (e.g., gender, age, location) challenging [314].

The above mentioned test batteries currently use norm-referenced or criterion-referenced standards, whereby individuals can compare their fitness levels for each of the given fitness components to set standards or goals [315-317]. The Australian Fitness Education Award is one such program, and sets standards for children and adolescent's physical fitness levels (called Physical Activity Zones), where minimal standards of fitness for achieving health gains are identified [317]. However, the standards of fitness differ across each of the programs and evidence to support program recommendations is limited.

One recent study by Adegboye et al., (2011) attempted to define the optimal cut-off for low aerobic fitness (using VO_2Max.) and to evaluate its accuracy in predicting the clustering of risk factors for cardiovascular disease in children and adolescents [318]. Using a cross-sectional database of 4500 school children (aged 9–15 years) from Denmark, Portugal, Estonia and Norway, Adegboye et al. (2011) concluded that in girls, the optimal cut-offs for identifying individuals at risk were: 37.4 mlO_2/min/kg (nine years old) and 33.0 mlO_2/min/kg (15 years old), and in boys, the optimal cut-offs were 43.6 mlO_2/min/kg (nine years old) and 46.0 mlO_2/min/kg (15 years old) [318].

2.8 Physical Fitness Levels of Children

CRF is the most commonly investigated fitness component and the available evidence suggests that health-related fitness levels in children and adolescents have declined over the last 20–30 years [12-21] and that there is great global variability in fitness levels [319]. Table 2.2 displays international studies reporting health-related fitness variables and the associated fitness trends. Tomkinson and Olds (2007) calculated secular changes in CRF for 161,419 Australasian 6–17 year olds between 1961 and 2002. Overall, performance in this sample declined at an average rate of -0.24% per annum, with the greatest declines experienced between 1960 and 1990, and a reduced decline until 2002 [320].

Table 2.2: Fitness Levels and Trends of Children and Adolescents

Country Date	Sample	Health-Related Fitness Component	Findings
Australia [166] 2004–2010	N = 8100 Grades K, 2, 4, 6, 8 & 10	BC (BMI) CRF (20mSRT)	No change in overall rates OO = 22.8% OO sig. increase in K, 2, 6 & 10 OO sig. decline in grades 4 & 8 ♂OO < by 0.18%/year (24%) ♀OO > by 0.17%/year (21%) ♂CRF > by 0.7%/year ♀CRF declining 72.1% Grade 4 meeting CRF guidelines 66.5% 6, 8 & 10 meeting CRF guidelines
Germany [178] 2003–6	N = 4529 4–17 yrs	CRF (bike ergometer) MF (standing jump, counter-movement jump, push-up) F (forward bend)	CRF and MF > from childhood to puberty (♂♀) CRF(♂♀) and MF(♂) > from 11–17 (B) Age and gender differences
UK [321] 1998–2010	N = 27,942 9–11 yrs	CRF (20mSRT)	CRF annual decline of 1.34% (♀) and 2.29% (♂)
Brazil [19] 2007	N = 2848 6–18 yrs	F (sit & reach, trunk lift) MF (curl-up, push-ups) CRF (PACER)	% reaching recommended level 63.4(♀) / 72.3 (♂) = F 23.8(♀) / 31.2 (♂) = MF (curl up) 53.2 (♀) / 75.6 (♂) = F (trunk lift) 30.7 (♀) / 48.7 (♂) = MF (Push-up) 32.3(♀) / 44.1 (♂) = CRF (PACER) < 8% meeting requirements in all tests % declined with age for all tests
Denmark [246] 1985–1998	n1 = 1369 n2 = 589 9 yrs	CRF = bicycle ergometer BC (body fat / skinfolds)	♂ lower CRF (bike ergometer) ♂ higher body fat (skinfolds) > polarisation b/t highest & lowest CRF by 7%, body fat scores by 2.4% for ♂ & ♀ ♀ no change in mean CRF or obesity Obesity levels > from 2.3% to 4.1%
Denmark [322] 1980–2006	n1 = 2050 n2 = 2603 9–12 yrs	BC (height, weight) Neuromotor fitness test	♂ & ♀ taller and heavier ♂ & ♀ sig. decline fitness tests
Lithuania [323] 1992–2002	N = 2009 12, 14 & 16 yr olds	*Eurofit Test Battery:* BC (height and weight) F (sit and reach) MF (standing broad jump, sit-ups) CRF (20mSRT)	♂ & ♀ (all three age groups) < F 19.8% < CRF from 30.0–46.0% > MF (sit-ups from 3.5–7.3%) ♀ < MF (jump test from 4.9–5.5%) ♂ & ♀ BMI > (not sig.)
Northern Ireland [271]	n1 = 1015 n2 = 2017	BC (BMI, body fat % skinfolds)	♂ & ♀ height & weight > in all age–sex groups

Country Date	Sample	Health-Related Fitness Component	Findings
1989–2001	12 yrs & 15 yrs	PA (self-report questionnaire)	♂ & ♀ > overweight/obesity (15.0 to 19.6%)(greatest in 12 yrs) ♂ Increases BMI (19.2–20.3 kg/m2) 12 yrs and ♂ < PA score 12yrs
Eastern Germany [324] 1880–2006	N = 22,667 7–14 yrs	BC (BMI)	Increase average BMI of the 7 to 14 year olds 1.8 kg/m(2)♀and by 2.1 kg/m(2)) ♂
Portugal [325] 2006–2008	N = 345 11–19 yrs	FITNESSGRAM: MF (curl-ups, push-ups) CRF (20mSRT) PA (self-report questionnaire)	♂& ♀increase height and weight, BMI, MF (curl-up & push-up) ♂& ♀decrease in overall fitness score, CRF (20mSRT)
New Zealand [272] 1991-2003	N = 3306 10–14 yrs	BC (height, weight, BMI) F (sit & reach) MF (standing broad jump, curl-up) Agility (469-m agility run) CRF (550-m run)	> weight ♂4.5 kg (0.8% per year) and ♀3.9 kg (0.7% per year). > BMI ♂(0.6%) and ♀(0.5%)/year Decline CRF ♂1.5% ♀1.7%/year Heaviest children performed worst on all tests
Georgia, US [326] 2006–7	N = 5348 10–13 yrs	FITNESSGRAM CRF(15m PACER) BC (BMI) MF (trunk lift, curl up, modified pull-up) F (sit & reach / trunk lift) PA (3DAY recall)	52% below healthy CRF 23% below standard for MF (strength & endurance) & flexibility 30% were outside the recommended range for BMI 22% below 60min MVPA/day All subgroups (e.g., boys/girls, urban/rural) scored poorly.
Aragon, Spain [273] 2007	N = 1068 7–12 yrs	BC (skinfolds – body fat, BMI) CRF (20mSRT) MF (handgrip, bent-arm hang) F (sit & reach)	OO♂35% OO♀41% > rates of OO CRF significant predictor of BMI and body fat)
Greece [327] 1992-2007	n1 = 606 n2 = 361 5–8 yrs	F (sit & reach) MF (standing-broad-jump, sit-ups) CRF (20mSRT) European-PF MVPA (PA questionnaire)	♂(27%) & ♀(17%) Increase MF (SBJ) ♂(18%) & ♀(43%) Increase MF (sit-ups) ♂(22%) & ♀(13%) Increase F ♂(21%) & ♀(26%) Increase CRF Increase MVPA (49%) ♂
Asia [328] 1917–2003	N = 23,500K 6–19 yrs	MF (standing jump), speed (sprint) CRF (range of cardiovascular endurance tests)	Little change in power & speed Consistent decline in CRF across all studied Asian nations (past 10–15 years)

Country Date	Sample	Health-Related Fitness Component	Findings
Canada [220] 1981–2007	N = 5116 6–19 yrs	MF (grip strength, partial curl-ups) F (sit & reach) CRF (mCAFT—modified Canadian Aerobic Fitness Test) BC (BMI & WC)	♂ & ♀decline in CRF (32% & 20% below recommended standard) ♂ & ♀ decline in F (13% and 22% below recommended standard) ♂ & ♀ decline in muscular strength (59% and 47% below recommended standard) ♂ & ♀ muscular endurance (20% and 38% below recommended standard) ♂ & ♀ Significant increase BMI & WC
Scotland [329] 2012	N = 276 10 years	BC (height, weight) CRF (20mSRT) MF (standing broad jump)	82.9 % not meeting CRF recommendations 81.6% not meeting strength recommendations ♀15% and ♂8.4% Obese ♀23.5% and ♂23.3% Overweight 38.2% low activity

BC = Body composition
MF = Muscular fitness
BMI = Body mass index
OO = overweight / obesity
♀ = girls / female
> increased
CRF = Cardiorespiratory fitness
F = Flexibility
PA =Physical activity
♂ = boys / male
WC = waist circumference
> decreased

Tomkinson and Olds also found a precipitous decline in the CRF of children across 27 countries since 1970, that secular changes were reasonably similar for boys and girls [330] and in comparison to children of similar age across the globe, Australian children demonstrated poor to average aerobic fitness levels [21]. Considering the positive association between participation in physical activity and improvements in physical fitness (especially CRF) [221, 331-333], and the recent data suggesting a decline in physical activity amongst children and adolescents, it is not surprising that physical fitness levels have followed a similar trend.

2.9 Conclusion

Available evidence supports the important contribution that high levels of physical activity and health-related physical fitness have in achieving numerous positive health outcomes in children and adolescents. Nonetheless, global trends indicate that children and adolescents are inadequately active and that many children are not meeting recommended health-related fitness levels.

The following chapter describes the role of the school in addressing physical activity and physical fitness trends in children and provides evidence for the success of previous school-based interventions for improving physical activity and physical fitness. Chapter Three also reviews key theories explaining the complex relationship between physical activity and physical fitness, and the numerous factors that influence individual physical activity participation in the school setting.

Chapter Three

The Role of the School and the Effect of School-based Interventions on Improving Physical Activity and Physical Fitness

This chapter provides a review of the impact of recent school-based physical activity and physical fitness interventions and examines the relevant theoretical frameworks for understanding physical activity behaviours in children and adolescents. Evidence around the implementation of recent physical activity interventions are discussed, with particular reference to interventions guided by the Health Promoting School Framework, Social Cognitive Theory, Competence Motivation Theory and Ecological theories. Figure 3.1 summarizes the structure of Chapter Three.

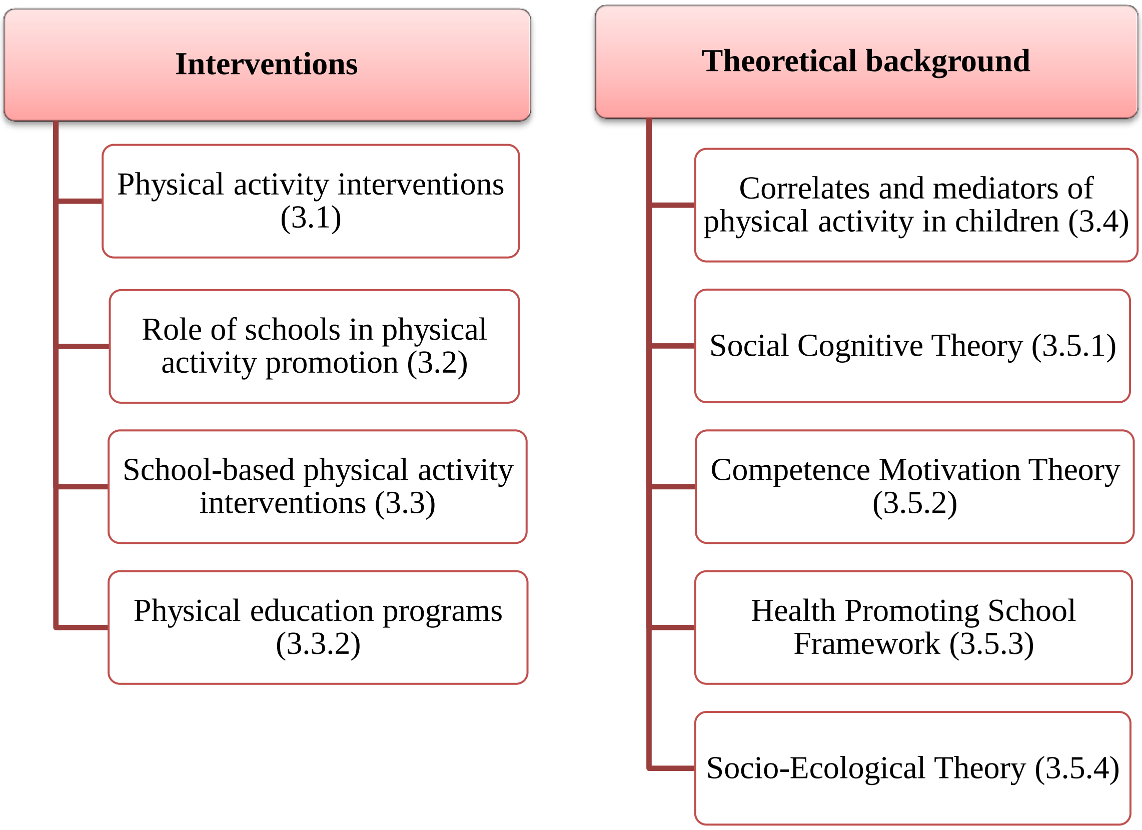

Figure 3.1: Structure of Chapter Three

3.1 Physical Activity Interventions

The development of feasible and effective physical activity interventions for children and adolescents has emerged as an important health promotion strategy. The literature continues to build and provide support for the effectiveness of school-based physical activity interventions for improving various measures of physical activity and health [50, 51]. However, evidence of the effectiveness of interventions for improving objectively measured physical activity across a range of settings (i.e., school, home/family, community) has been mixed. Van Sluijs et al. (2011) reviewed the effectiveness of family- and community-based physical activity interventions targeting children and adolescents, and found that although improvements in study quality are evident, the effects on physical activity behaviours are minimal [52]. The authors concluded that the most effective family- and community-based studies targeted families in the home setting. Similarly, a recent review of interventions for improving physical activity across five settings (home/family, community centre, gym, after hours school setting and scout centre based) conducted by Metcalf and colleagues (2012) [56] and a meta-analysis of behavioural interventions for children outside the school setting by Kamath et al. (2008) [53], showed limited evidence of success in improving physical activity levels. What is clearly required is the identification, and targeting, of the settings that are most effective in facilitating positive physical activity behaviours (such as in the school context).

3.2 The Role of Schools in the Promotion of Physical Activity and Fitness

The school, via the curriculum, school ethos and physical environment, has been universally identified as an important institution for the promotion of physical activity in children and adolescents [31, 40, 41, 334]. The school is an ideal setting for providing students with opportunities to be physically active and for education about the importance of physical activity and the value of achieving and/or maintaining health-related fitness standards [335]. In recent times, the focus on facilitating physical activity via the school setting has increased and there is more pressure on teachers to equip children with the necessary skills to be physically active within and beyond the school setting [199]. There are numerous opportunities for the promotion of physical activity and for the development of essential knowledge, attitudes and skills regarding physical activity in the school setting. The most commonly utilized opportunities for children and adolescents include health and physical education lessons, school sport, recess and lunch breaks, before and after school care, active school transport options, subject integration activities and active homework [30]. School-based interventions targeting these opportunities are becoming increasingly common and have great potential for improving physical fitness levels given that:

- children are highly accessible;
- children spend a large proportion of their time at school;
- physical activity programs can be potentially embedded into the regular school curriculum, staff development and school infrastructures [336];
- interventions delivered in the school setting are cost-effective [337, 338].

3.3 School-Based Physical Activity Interventions

Schools have been targeted as a key setting for implementing programs aimed at increasing the physical activity and physical fitness levels of children [31, 40, 41, 334]. Consequently, a growing number of small and large-scale school-based physical activity interventions targeting children and adolescents have been implemented and evaluated in many countries, with varied levels of success [49, 50, 54, 57-60]. A recent Cochrane review of school-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6 to 18 years conducted by Dobbins et al. (2013), reported that school-based physical activity interventions can be effective in improving cardiorespiratory fitness, increasing the number of children engaged in MVPA, and increasing the length of time spent engaged in these activities (although the authors cautioned that moderate levels of risk of bias should be considered when interpreting the results) [50]. Studies from Australia, South America, Europe, China, and North America were included in the review and differed in terms of: intervention duration (ranging from 12 weeks to six years); methods of delivery (e.g., classroom teacher vs. specialist PE teacher); included program components (e.g., curriculum, information, recess, homework, family involvement); data collection; and theoretical framework [30, 50]. Programs often consist of a physical activity, environment or curriculum component only (e.g., increased physical education or building additional play equipment) [339-347]; a combination of physical activity and educational components [340, 348-356]; or a combination of physical activity, educational and/or environmental components [341, 357-359]. There were no studies in the Cochrane review that used a Health Promoting School Framework, where the intervention combined an educational component (that aligned with the existing health and physical education curriculum), with a recess/lunch environmental component and a home/family to target physical activity behaviours [50]. Furthermore, there are limited studies identifying the specific components of the program that mediated changes in physical activity.

Table 3.1 provides a brief summary of the methods and findings of recently published school-based physical activity and physical fitness randomized controlled trials targeting children. The physical activity interventions summarized are indicative of the range of studies being implemented worldwide. Although the methodological quality of studies has improved in recent years, limitations still exist. First, several studies are under powered to detect changes in physical activity and physical fitness outcomes or are limited in their ability to generalise results due to small sample size [360-364], the use of objective measures of physical activity are inconsistent, and physical fitness assessment tools vary in validity and reliability. Furthermore, intervention strategies differ immensely between studies and the multi-component nature of many school-based interventions makes it difficult to evaluate program impact on physical activity and fitness outcomes. Many of the studies above have reported limited intervention effects on fitness outcomes, particularly on body composition [360-362, 365-368], cardiorespiratory fitness (contradicting the Cochrane review [50]) [361, 365, 368, 369], and muscular fitness [360] – or don't specifically target physical activity and all of the health-related fitness components. Furthermore, many of the above studies do not combine educational program components (via curriculum learning activities) with practical physical activities [360, 363, 364, 366, 368-370], or extend learning beyond the classroom [360, 361, 366, 369]. Therefore, despite the fact that some studies have reported positive intervention effects in selected outcomes, the potential for the study to facilitate large scale behaviour changes in all areas of physical activity and fitness may have been limited. Popular behaviour theories contend that for behaviour change to occur, an individual needs to build a repertoire of individual skills and competencies relating to physical activity behaviours, develop confidence in their abilities to perform various physical activities, understand and appreciate the value of a adopting healthy behaviours through education and be fully supported in the social and physical environment [74, 371-373]. Evidently, large scale programs that target physical fitness and physical activity via curriculum-based learning activities that extend beyond the classroom are clearly needed.

Table 3.1: Findings from recent school-based physical activity and physical fitness interventions

Author/s	Time	Sample	Methods	Findings
Magnusson, Hrafnkelsson, Sigurgeirsson, et al. [365]	2012	T(n) = 151 C(n) = 170 Age: 7yrs	2-year cluster-RCT PA/dietary program	No effect on BC Inconclusive effect on CRF
Cichy & Rokita [361]	2012	N = 127 grade 1 4 x schools in Poland	RCT Daily PA using EDUballs	International Physical Fitness Test: No impact on PF
Katz, Cushman, Reynolds, et al. [366]	2010	5 schools US n = 1214 Grades 2–4	RCT ABC (Activity Bursts in the Classroom) for Fitness program, Teacher training Family component	Sig. improvement in upper-body, abdominal, and trunk extensor strength Medication use for asthma, ADHD or either medication combined decreased
Thivel, Isacco, Lazaar, et al. [367]	2011	N = 457 Age: 6–10 years T(n) = 229 C(n) = 228 19 schools in France	• RCT • 6 month PA program • 2 x PE classes (2 hours) + 2 x PA (2 hours) sessions/week • Exercises to improve coordination, flexibility, strength, speed, and endurance	• No effect BC • Sig. improvement in lower limb muscular power and heart rate reserve (indicator of CRF)
Aburto, Fulton, Safdie, et al. [369]	2011	N = 699 Grades 4 & 5 mean age 10.2 yrs 27 schools in Mexico	• RCT (3 armed) • School environment and policy changes to enhance PA • 6 month intervention • Daily exercise session	• Sig. improvements in PA • Small improvement in MF (sit-ups) • No change for flexibility or CRF
Gorely, Nevill, Morris, et al. [368]	2009	8 primary schools in UK (4xT, 4xC) N = 589 Aged 7–11 yrs	• Non-randomized CS • 10 month intervention • CD-Rom teaching resource • Interactive website • 2 PA events • activity wall planner	• Positive changes in PA levels (MVPA/VPA/TPA) and BC • No effect on consumption of fruit and vegetables

Author/s	Time	Sample	Methods	Findings
Duncan, McPhee, Schluter [363]	2011	8 classes grades 5–6 New Zealand T(n) = 57 C(n) = 40 control age = 9–11 yrs	• 6-week 'Healthy Homework' program + teaching resource • RCT	• Sig. treatment effect on PA (steps), vegetable consumption, and unhealthy food consumption on weekends • No effect on screen time, sports participation, active transport to and from school
Michaud, Nadeau, Martel, et al. [364]	2012	4 x schools 5th grade Age = 10–11yrs T(n) = 86 C(n) = 82 girls & boys	• RCT • Promoting Lifetime Activity for Youth (PLAY) program • 12 week intervention • 4-weeks – daily 15-min activity break at school (variety of games and activities) • 8-weeks – 30 min daily PA (outside of school five times/week (student directed)	• Sig. increase in PA volume • Boys increased PA levels by more than the girls
Hall, Zeveloff, Steckler, et al. [370, 374]	2012	42 schools (T = 21, C = 21) Total n = 4603 Mean age = 11.3±0.6 yrs US schools	• 3 year trial • HEALTHY physical education MVPA • 225 mins per 2 weeks • 4 component program • cluster RCT	• Process evaluation results: • High level of fidelity • Dose: students were active 61% of the class time • Students were highly engaged with the PE intervention • Barriers: misbehaviour, teacher disengagement, large classes, limited gym space and poor classroom management • Sig. < BMI, BMI-Z score, waist circumference, and fasting insulin levels

RCT = randomized controlled trial
C = control
BC = body composition
PF = physical fitness
VPA = vigorous physical activity
PE = physical education

T = treatment
N = number
PA = physical activity
MVPA = moderate-to-vigorous physical activity
TPA = total physical activity

There have been several reviews analysing the effectiveness of school-based physical activity interventions. These are summarized below (Table 3.2). A recent review by Demetriou and Höner (2012) of 129 studies conducted between 2000–2010, identified that the majority of physical activity studies were conducted in North America (55 studies) and Europe (54 studies), with the USA (49 studies) and Great Britain (14 studies) among the countries with the highest number of studies [57]. There were also a high proportion of studies (70.5%) targeting children (aged 6–12 years), with less (27.1%) focusing on adolescents (aged 13–19) or both children and adolescents (2.3%) [57]. The focus on interventions for primary school-aged children, especially upper primary, is likely due to the increased flexibility offered by the primary curriculum (i.e., the daily curriculum program can be manipulated given that in general, the same teacher delivers all subjects throughout the day). Furthermore, reviews have confirmed that the quality of recent school-based physical activity interventions is relatively high, and evidence is reported for their effectiveness in improving physical activity behaviour and fitness (specifically cardiorespiratory fitness), especially when the program utilizes family involvement and has a multicomponent program structure (including physical education, activity breaks, and family strategies) [375, 376]. Of note, is that Dobbins et al. (2013), Demetriou & Höner (2012), and Harris et al. (2009) [377] concluded that school-based physical activity interventions have shown limited effects for improving body composition in children.

In summary, the literature shows that school-based physical activity interventions are becoming more widespread as a means of targeting the physical activity levels and cardiorespiratory fitness levels of primary school children, and have shown some success. There are limited studies targeting, or reporting on, muscular fitness outcomes (or other fitness components), and intervention effects on body composition are limited. Furthermore, many existing studies do not combine educational program components with practical physical activities, extend learning beyond the classroom, or refer to existing theoretical frameworks in program design, potentially limiting the potential impact of many studies.

Table 3.2: Reviews of Physical Activity Interventions Targeting Children and Adolescents (since 2000)

Author/s	Year	Summary	Findings
Sun, Pezic, Tikellis, Ponsonby, Wake, Carlin, Cleland, Dwyer [60]	2013	Systematic review of the effects of school-based interventions for direct delivery of physical activity on fitness and cardiometabolic markers in children and adolescents	• Some large, higher quality RCTs provided strong evidence for interventions to decrease skin-fold thickness, increase fitness and high-density lipoprotein cholesterol. • Evidence for blood pressure and triglycerides, low-density lipoprotein cholesterol and total cholesterol remain inconclusive.
Dobbins, Husson, DeCorby, & LaRocca [50]	2013	Review of school-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6–18yrs	• Some evidence that school-based PA interventions had a positive impact on four of the nine outcome measures (duration of PA, television viewing, VO_2 max, and blood cholesterol). • Generally, school-based interventions had little effect on PA rates, systolic and diastolic blood pressure, BMI, pulse rate.
Demetriou, & Höner [57]	2012	Systematic review of school-based controlled studies that involved a PA intervention targeting school students	• Significant treatment effects on BMI, motor performance, PA and psychological determinants. • Intervention effects were moderated by students' age, type and frequency of interventions. • Mediator effects of self-efficacy between program and students' PA.
Saraf, Nongkynrih, Pandav, Gupta, Shah, Kapoor, & Krishnan [59]	2012	A systematic review of school-based interventions to prevent risk factors associated with non-communicable diseases	• The review provided support for the effectiveness of school-based interventions for prevention of risk factors associated with NCDs. • Of the 37 studies reviewed 10/12 involving the family, 7/8 involving both community and family, and 13/17 involving the school only, 80% reported at least some evidence of a positive intervention effect.
Camacho-Minano, LaVoi & Barr-Anderson [378]	2013	Narrative systematic review of interventions to promote PA among young and adolescent girls	• The review found that 10/21 studies reported a favourable intervention effect on PA outcomes, where multicomponent school-based interventions address the unique needs of girls via PE programs, and those using peer strategies, were most effective.
Lubans, Morgan, Tudor-Locke [379]	2009	Systematic review of the effectiveness of pedometers in promoting PA among	• The review reported that 12/14 studies using pedometers resulted in increases in PA, implying that pedometers are a useful tool for promoting activity among youth.

Author/s	Year	Summary	Findings
		youth.	
Dobbins, De Corby, Robeson, Husson & Tirilis [380]	2009	Systematic review of school-based PA programs for promoting PA and fitness in children and adolescents aged 6-18	• Of the 26 studies included in the review, there was good evidence that school-based PA interventions have a positive impact on four of the nine outcome measures (duration of PA, television viewing, VO2 max, and blood cholesterol) • Generally school-based interventions had no effect on leisure time PA rates, systolic and diastolic blood pressure, body mass index, and pulse rate.
De Meester, van Lenthe, Spittaels, Lien, De Bourdeaudhuij,	2009	Systematic review of studies (1995–2008) promoting PA among European teenagers	• The review of 20 relevant studies containing various program components supports the short-term effectiveness of school-based PA promotion programs. • Effective components included the inclusion or parental support and peer strategies, along with direct changes to the environment. • The available evidence for the effectiveness in other settings is limited
Hoehner, Soares, Parra Perez, Ribeiro et al [381]	2008	Systematic review of PA interventions in Latin America	• Little support for previous interventions for improving PA except for school-based PE classes in Latin America.
van Sluijs, McMinn & Griffin [382]	2007	Systematic review of controlled trials promoting PA in children and adolescents	• The effect of family- and community-based interventions remains uncertain despite improvements in study quality. • Of the little evidence of effectiveness, most comes from those targeted at families and set in the home.
Salmon, Booth, Phongsaven, Murphy & Timperio [383]	2007	A narrative review of interventions promoting PA participation among children and adolescents	• Interventions delivered in the school setting that included: curriculum changes to PE, activity breaks, family strategies or changes to the environment were the most effective among children. • For adolescents, interventions in primary care settings and tailored advice/brief counselling appeared to be most effective. Intervention targeting the family setting was limited.
Cale & Harris [30, 384]	2006	A review of reviews of school-based interventions to promote children and adolescent's PA	• The evidence reviewed revealed that school-based PA interventions can be effective and achieve a range of positive outcomes.
Trudeau & Shephard [385]	2005	Review of the contribution of school programs to PA levels and attitudes in	• The review suggests that a sufficient quantity of a quality PE program can contribute significantly to the overall amount of MVPA of the school-age child.

Author/s	Year	Summary	Findings
		children and adults	
Timperio, Salmon & Ball [56]	2004	Review and update of evidence-based strategies to promote PA among children, adolescents and young adults	• The review found that PA studies that incorporated whole-of-school approaches including curriculum, policy and environmental strategies were found to be more effective than those that incorporated curriculum-only approaches • PA/sedentary behaviours also improved in other settings and that interventions that included contact with families generally appeared to be most effective. • Majority of findings were of short term rather than of sustained increases in PA.

PA = physical activity

BMI = body mass index

PE = Physical Education

BMI = body mass index

BF = body fat

WC = waist circumference

3.3.1 The Effectiveness of Single Component School-Based Programs

Recess / Lunch Components

Participation by children in a range of physical activities and unstructured play during school recess and lunch breaks has been shown to be a powerful developmental (physical, cognitive and social) and learning tool that may complement the formal physical education curriculum [386-388]. Recently, there has been growing interest in engaging children and adolescents in higher levels of physical activity during recess and lunch breaks, and in improving the school physical environment to maximize physical activity opportunities [195, 388-390]. Consequently, environmental interventions have emerged as a popular method for increasing children’s physical activity during the school day [382]. A few school-based studies have been effective in improving the physical activity levels of children (and the intensity of physical activity), by targeting the recess environment using games or sports equipment [341, 347, 391, 392] and playground markings [341, 346, 393, 394]. Although the methodology is varied and the number of available studies is limited, studies have successfully shown that the provision and accessibility of activity promoting equipment and playground markings may facilitate active behaviours in children [195, 341, 346, 347, 393, 395].

Consequently, there have been a number of recommendations in relation to physical activity participation during recess, and effective strategies for maximising this critical time during the school day [396]. These include: providing inexpensive playground equipment to encourage students to be more active, training recess supervisors/teachers to teach new games and interact with students informally, painting playground surfaces with lines or murals for recreation games, allocating playground space for designated 'activity zones' or sports, ensuring that all students have access to spaces and facilities, having exercise-friendly uniforms (especially for girls), promoting peer support for physical activity at recess, and combining several low-cost approaches (e.g., providing equipment, game ideas and spaces) [197, 396]. In summary, this research highlights that providing an optimal physical and social environment at school during recess and lunch is an effective and efficient way to increase physical activity among children during the school day [155].

Active Homework Components

The home environment provides an ideal setting to extend learning and health promotion beyond the classroom and school playground [397]. Homework tasks that involve physical activity, and also complement and extend the learning activities in a range of subject areas (e.g., health and physical education, maths, geography, creative art and English), provide children with opportunities to increase their total physical activity levels, develop their fitness levels and build on essential academic, social and physical skills. Previous research shows that children are considerably less physically active on weekends than on weekdays [398-400], and that active children achieve a significantly greater proportion of their activity outside of school than inactive children [400, 401]. Utilizing this time has the potential to not only improve the health of children, especially of the children who are insufficiently active, but to also encourage parents to support their child in reaching physical activity and fitness education goals.

There are limited school-based studies focusing on the promotion of physical activity and/or physical fitness outside of school via homework or home activity components. It is also difficult to determine the contribution of the homework component of a multi-component program for facilitating changes in health behaviours – especially when the homework tasks vary considerably. The available data shows mixed results for achieving physical activity outcomes, with some interventions reporting a positive effect [402] and others showing little or no effect [363, 403-408]. A recent short-term study by Duncan et al. (2011) examined the efficacy of a six-week compulsory homework program for increasing physical activity and healthy eating in grades 5 and 6 amongst New Zealand children [359]. Duncan reported significant positive treatment effects on physical activity, with children in the intervention schools exhibiting an average increase of 2830 steps/day (25% increase) [363], demonstrating that health-related homework has the potential to be an effective approach for increasing physical activity in children. However, there is limited research examining the effectiveness of physical activity homework components when used in conjunction with a school-based physical activity or fitness education program. Additionally, Australian schools are not required to have a specialist physical educator in primary schools and generally the classroom teacher is responsible for the delivery of health and physical education lessons (some State, Independent and Catholic schools do have specialist teacher).

3.3.2 Physical Education Programs

Quality physical education has been shown to have a positive effect on children for physical, lifestyle, affective, social and cognitive domains [409-412]. High-quality physical education can provide students with the appropriate knowledge, skills, behaviours, and confidence to be physically active [39, 413, 414], and is central to achieving physical activity and physical fitness goals in the school setting [415-418]. The modification of existing physical education programs in primary and secondary schools has been shown to be a popular and somewhat effective strategy used by researchers looking to improving physical activity in children and adolescents [411, 419-421].

Research has shown that, for some children, physical education provides the main avenue for being physically active [409, 422], yet, there is increased pressure by governing bodies to reduce the amount of time allocated to mandatory physical education lessons in many countries due to increased competition with other academic areas [67, 423, 424]. A global report suggests that, within the general education system, a majority of countries (81% primary schools; 82% secondary schools) have legal requirements for physical education in schools, and the percentage rises to 92% when the countries are added which have no compulsory requirement for physical education but where it is generally practised (in the European region, it is all countries) [67]. In terms of other countries the time allocated to physical education is highly variable and is rarely monitored, but across primary school years there is an average 94 minutes (with a range of 30–180 minutes) and in secondary schools, there is an average of 101 minutes (with a range of 45–250 minutes) per week [67].

A recent investigation of Californian primary schools, reported that school compliance with state-level physical education policies is related to fıtness levels in younger students [418], suggesting that greater attention should be given to documenting whether schools are actually implementing mandated curriculum time in physical education. In NSW Australia, The Department of Education and Communities (DEC) has acknowledged the importance of physical activity in primary schools by requiring schools to deliver two hours per week of planned physical activity [41]. The DEC does not, however, monitor achievement of this target, how much time they spend on MVPA, or the quality of the physical activity programs (e.g., sport, health and physical education). The NSW SPANS 2010 estimated that 30% of primary schools do not deliver two hours of mandated physical education and sport each week [171]; but it is important to note that this was based on Principal-reports and is likely much worse than this.

Physical Activity in Physical Education

To improve physical activity levels within existing physical education lessons, researchers have augmented physical education programs by lengthening the time of existing physical education lessons, conducting additional lessons, increasing the amount of physical activity during lessons (via changes in teaching practices and strategies), and by improving the quality and quantity of educational information [30, 421]. However, studies have questioned the quality and quantity of health and physical education lessons delivered in schools, especially primary schools [36, 67]. The Hardman report [67], suggests that many physical education programs focus on sports-dominated, competitive, and performance-related activity programs (e.g., dominated by games, track and field athletics and gymnastics), which questions the meaning and relevance as well as quality of the physical education delivered [67].

Studies have identified a range of barriers reported by teachers in their ability to achieve important student outcomes in a range of health and physical education topics. Although primary school teachers have been shown to have a positive attitude towards physical education and value its inclusion in the curriculum [425], barriers such as lack of training and knowledge, a crowded curriculum, lack of confidence, lack of interest, little accountability or incentive for delivering sufficient, good quality physical education programs, and limited space and facilities have been noted [41, 65-70]. The broad scope of the health and physical education curriculum, the large array of learning objectives in this subject area in the primary school curriculum and the limited mandatory curriculum time allocated to health and physical education in many countries (60 min in Australia), also make it difficult for classroom teachers to implement programs that increase the amount and intensity of student physical activity, let alone create the training effects required to improve physical fitness.

Based on a review of 44 studies, it appears that children are only active for a third of their total physical education time [426]. Other recent studies have suggested that these levels are as low as 13% of total time spent in physical education [427]. Although some studies have demonstrated that physical education contributes substantially to children and adolescents's overall physical activity, based on the low levels of MVPA in many lessons, there is considerable room for improvement [428]. The core of the difficulties faced by teachers in delivering high quality and high activity lessons in physical education may be attributed to a lack of readily available curriculum-based programs and resources available to schools that extend learning beyond the confines of the classroom [37]. Teachers have reported a desire to have access to up-to-date and expertly developed programs that not only give them ideas for quality teaching in health and physical education but that also give them specific instructions and strategies on how to teach a variety of health and physical education topics and to facilitate the learning of essential knowledge and skills [65].

Several researchers have responded to the call to improve the quality of primary school physical education and to increase the active participation by children in physical education. A review by Lonsdale et al. (2013) reported that programs designed to increase the amount of time that students are engaged in MVPA (with a target of > 50% of physical education lesson time) can be effective with students in intervention conditions, spending 24% more lesson time in MVPA compared with students in usual practice conditions (standardized mean difference = 0.62) [421]. Two highly successful studies, the Child and Adolescent Trial for Cardiovascular Health (CATCH) intervention [406] and the Activity-based Physical Education (AB-PE) intervention [420], increased the average percentage of time spent in MVPA during physical education lessons from 37.4% at baseline to 51.9%, and from 38.4% to 58.7%, respectively.

Successful physical education programs used two key strategies to increase student time in MVPA. First they were shown to implement a well-designed curriculum, that recommends the use of a range of highly active games, fitness activities, and circuits delivered through direct and explicit teaching strategies; and second, these programs provided teachers with appropriate training and resources [58, 340, 349, 406, 420, 429-431]. With regard to physical activity, Kahn et al. (2002) reported consistent increases in time spent in physical activity at school in 13 reviewed studies targeting physical education [419]. These improvements were observed in the amount or proportion of time spent in MVPA in physical education classes and in energy expenditure (e.g., [349, 406, 408, 430-434]). However, there is limited data on the effectiveness of physical education programs for improving a range of fitness outcomes. Therefore, it is recommended that a whole-school multi-component approach may be effective in facilitating changes in physical activity, but utilizing a range of strategies implemented across various times of the day and the measurement of fitness outcomes is an area that needs exploring [30].

Physical Fitness through Physical Education

The importance of designing, implementing and evaluating quality health-related fitness programs for children has emerged in the literature [49, 380, 411, 435]. A growing number of researchers across several countries are evaluating primary school interventions to improve physical activity and fitness in the U.S., Europe and New Zealand. Interventions such as CATCH [436], KISS [437] and SPARK [431], along with a few small-scale HRF programs [438-442], have demonstrated some positive results in improving physical activity and fitness levels. Programs involving high intensity exercise over a short intervention period during the school day, have also been shown to consistently improve several components of physical fitness, including cardiorespiratory fitness, muscular fitness and agility in adolescents [443], and improve their general health status [444, 445]. The development, implementation and evaluation of fitness education programs in the health and physical education curriculum is an area of great health promotion potential.

Fitness education, including fitness testing, has traditionally been an important component of the physical education curriculum in many developed countries [446]. However, over the past two decades some researchers have argued for the removal of physical fitness testing in the physical education curriculum [310, 447, 448]. In the past, fitness testing in schools frequently dominated the fitness education program or was performed in isolation, where the testing environment often invoked embarrassment and anxiety for students [448, 449]. However, the fitness testing methods available for use in schools have evolved from a performance model to a model that considers health-related outcomes [317], with test interpretations now employing criterion-referenced standards in contrast to the previous norm-referenced systems

[310, 311]. These criterion-referenced standards specify the acceptable levels of fitness that are associated with a positive health status (e.g., metabolic risk syndrome) as opposed to comparisons based on the 'normal' performance results for individuals, differentiated by age and sex [315, 317, 450].

Fitness training and assessment within a comprehensive health and physical education curriculum (primary and secondary school), can serve many purposes [449]. It may help to promote individual physical activity, facilitate the learning of physical fitness concepts, and help children link health-related fitness to present and future health status [449]. Fitness assessments can also enable children to evaluate their fitness levels, develop physical activity goals, monitor progress in achieving the recommended levels of fitness, motivate children to adopt physically active lifestyle behaviours at school and at home and provide useful information to parents [451]. In addition, fitness testing may be used to evaluate the effectiveness of short-term physical education programs in achieving specific fitness outcomes or goals, and to guide the future development of these programs. An important study by Graser et al. (2011) recently examined children's perceptions of the FITNESSGRAM (administered in a self-testing format), children's understanding of the purpose of fitness self-testing, and the effects of participation in the FITNESSGRAM self-testing on children's perceptions of personal health [452, 453]. The authors reported that children enjoyed participating in the FITNESSGRAM using a self-testing format, understood the purpose of fitness self-testing, and were able to link their fitness test results to their overall health, providing support for the use of a fitness self-testing approach in physical education [452]. Importantly, it is recommended that fitness testing results should not be used to grade or compare students [446, 449].

3.3.3 Recommendations for Developing Effective School-Based Physical Activity and Physical Fitness Interventions

Preliminary recommendations have been made for developing effective school-based physical activity and physical fitness programs. Cale and Harris (2006) suggested that school-based physical activity programs should:

- complement and reinforce the health and physical education curriculum and be applied to the practical context;

- include family and/or community program components;
- address the target group's specific needs, interests and preferences;
- focus on a broad range of activities including non-competitive, recreational, individually oriented, unstructured, lifestyle activities;
- contain outcomes that are realistic and that focus preferably on behavioural (physical activity levels), cognitive (knowledge and understanding) and affective (attitudes) changes;
- include multi-level interventions that also address the physical activity environment; and
- provide flexible program delivery and organisation that afford children and adolescents choices [30].

Furthermore, it has been suggested that the educational institutes need to train teachers and staff to be supportive leaders, who are skilled and motivated (and regularly updated), and to provide easily accessible, good quality sports equipment, appropriate spaces and facilities [41]. However, the adoption of quality programs may prove difficult, with the latest reports indicating that around 30% of government primary schools (in Australia) do not provide two hours of planned health and physical education and sport each week, let alone two hours of MVPA activity each week (as planned time usually includes travel time, lesson organisation, administrative tasks, waiting in line and the like)[41]. These figures are based on Principal-report and the proportion of schools not meeting health and physical education, and sport requirements may be much worse. Furthermore, many government agencies are not actively enforcing or monitoring mandated physical education and sport time allocations in primary schools [41].

For effective evidence-based interventions to be developed and implemented in the future, it has been suggested that an examination of the underlying mechanisms causing changes in physical activity in school-based interventions is needed [57]. Michie and Abraham (2004) [42] proposed that we need to answer three key questions regarding behaviour change interventions (i.e., Do they work? How do they work? How well do they work?) [42]. An examination of the reviews summarized above, highlights that previous studies have not sufficiently addressed the third question in relation to physical activity (i.e., relating to the mediators of behaviour change). Furthermore, the effectiveness of physical activity interventions needs to be expressed in relation to theoretical frameworks, specific target groups (e.g., age) and the study designs chosen (e.g., methodological quality of the intervention) [42, 454].

3.4 Exploring Mechanisms of PA Behaviour Change in Children

3.4.1 Correlates of Physical Activity in Children

Identifying the correlates of physical activity occurring at different times of the day, locations and contexts, is an important step to understanding the complex nature of children's physical activity behaviour [455, 456]. Correlates of physical activity can be classified as demographic or biological, psychological, behavioural, and environmental, and vary by the degree to which they can be modified [457, 458] (see Table 3.3). Previous reviews have identified 40 correlates of children's physical activity – many of these being modifiable [459-461]. The most recent review of reviews conducted by Sterdt, Liersch and Walter (2014) identified 16 correlates which were consistently associated with physical activity of children and/or adolescents: sex, age, ethnicity, parental education, family income, socio-economic status, perceived competence, self-efficacy, goal orientation/motivation, perceived barriers, participation in community sports, parental support, support from significant others, access to sport/recreational facilities und time outdoors [458].

3.4.2 Mediators of Physical Activity in Children

There is a growing need for researchers to explore and report mediators of physical activity behaviour change in child interventions [71, 462]. Mediation analysis can be used to expand our understanding of behaviour change in children [463], as testing mediator variables allows researchers to determine which specific components of an intervention were linked to changes in physical activity behaviour [464]. Building evidence around these determinants will guide future intervention design and implementation.

A review of physical activity interventions that reported physical activity outcomes and potential mediators of behavioural change among children [462], identified 19 studies that reported both intervention effects on physical activity and mediators of behaviour change (e.g., knowledge, self-efficacy, enjoyment, attitudes, behavioural capability, intentions, outcome expectancies, social norms, social support and self-concept) [462]. Although several of the reviewed trials reported intervention effects on mediators, none of the studies reported whether changes in these constructs mediated changes in children's physical activity [462]. Similar conclusions were made by Demetriou and Höner (2012), and Lubans, Foster and Biddle (2008) in their reviews of physical activity intervention studies in children and adolescents, with both reviews reporting a lack of mediation studies – making it hard to conclusively identify mediators of physical activity behaviour change in children and in the school setting in particular [57, 71]. However, both reviews identified self-efficacy as the most commonly assessed mediator (of the three mediator groups: cognitive, behavioural and interpersonal), where self-efficacy demonstrated strong support for its role in mediating the relationship between theory-based interventions and physical activity [57, 71]. Van Stralen et al. (2011) conducted a systematic review of mediating mechanisms in school-based energy behaviour interventions and found consistent evidence for self-efficacy as a mediator of treatment effects on physical activity behaviour across 18 reviewed studies [465]. Similarly, Craggs et al. (2011) systematically reviewed determinants of change in longitudinal studies involving physical activity in children and adolescents, and also found support for self-efficacy as a determinant of change in physical activity in older children (10–13years) and adolescents [466]. There has been little evidence of mediation effects on physical activity for other personal, social or physical-environmental constructs targeted in school-based interventions [465, 467-469]. This may be due to the limited number of studies examining mediators of behaviour, variability in study design and quality, age-specific differences in physical activity behaviours and determinants of behaviour, limited research of psychological, behavioural, environmental factors and parent–child interaction, or limited availability of reliable and valid instruments to measure physical activity and its determinants in children and adolescents [71, 466].

Table 3.3: Reported correlates of physical activity for children and adolescents

Category	Correlates of Physical Activity
Demographic and biological correlates [116, 457-460, 470, 471]	Age (small/moderate *) Gender (male) (large +) Social status (+) Parent education (+) Migration background (+) Urban v rural environment (+) Body Mass Index (*)

Category	Correlates of Physical Activity
	Motor skills (+)
Psychological correlates [114, 457, 472, 473]	Motivation (+) Body image (+) Enjoyment of physical activity Physical activity self-efficacy Perceived acceptance by peers Parental encouragement Physical self-perceptions Self-concept (+) Perceived Competence (+) Depression (*) Enjoyment (+) Self-efficacy (+) Perceived barriers to physical activity (-)
Behavioural Correlates [457, 459, 460]	TV viewing/playing video games/ small screen leisure options (*) Time spent outdoors (+) Participation in organized sport (+) Healthy diet (+) Previous physical activity (+)
Environmental Correlates *(physical and social)* [116, 203, 214, 456, 457, 459, 460, 471, 472]	*School setting:* - Access to physical activity programs (+) - Condition of playing grounds /fields (+) - Access to loose and fixed equipment (+) - Playground markings (+) - Size of the playground (+) - Access to play space (+) - Provision of organized activities (+) - Length of school break-time (+) - Perceived support and encouragement from teachers and peers (+) - School ethos (+) (incl: school policies, physical education specialist, school size, class size, lesson-specific context - Supervision (+) *Home:* - Parental social support (+) - Direct parental support (+) - Parental role modelling - Involvement and social support provided by siblings (+)

(+) positive association

(*) negative association

3.5 A Review of Key Theories

A complex relationship exists between physical activity and physical fitness, and the numerous factors that influence individual physical activity participation in the school setting and in the home [464]. The literature increasingly provides evidence for the effectiveness of physical activity interventions that consider the Health Promoting School Framework and are grounded in credible theory – and, in the physical domain, there is a growing need for the integration of theories to increase intervention effectiveness. A review of the Health Promoting School Framework and the most utilized and supported theories will be presented, including, Social Cognitive Theory, Competence Motivation Theory and Socio-Ecological Theories.

3.5.1 Social Cognitive Theory

Health promotion theories suggest that, to motivate children to be physically active, multiple influences on their behaviour must be identified and addressed [46]. Bandura's Social Cognitive Theory has been used extensively as a conceptual framework for explaining health behaviours, such as physical activity in children [373]. Social Cognitive Theory proposes that behaviour (responses to stimuli to achieve goals), personal factors (psychological and biological), and environmental factors (social and physical) interact and influence each other in a manner known as reciprocal determinism (see Figure 3.2) below [474].

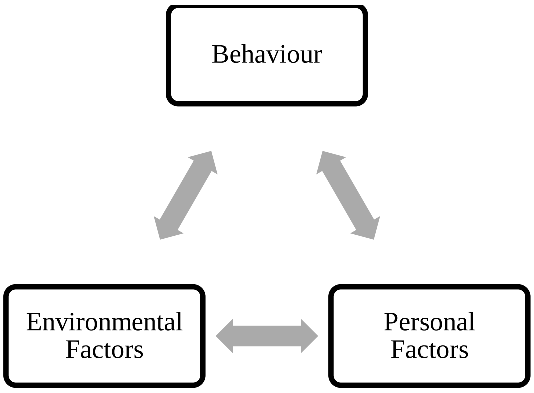

Figure 3.2: Reciprocal determinism

Reciprocal Determinism is the central concept of Social Cognitive Theory. The key variables within Social Cognitive Theory that are used to explain how individuals achieve, regulate and maintain behaviours over time (including physical activity behaviours) will be reviewed and are summarized in Table 3.4 [73, 475].

Table 3.4: Key concepts of Social Cognitive Theory

Key Concept	Description
Behavioural Capability	This refers to a person's ability to perform a behaviour using knowledge and skills.
Observational Learning	This asserts that people can observe a behaviour conducted by others, and then 'model' or reproduce the behaviour.
Reinforcements	This refers to the internal or external responses (positive and negative) to a person's behaviour that affect the likelihood of continuing or discontinuing the behaviour. These can be self-initiated or in the environment.
Expectations	This refers to the anticipated consequences of an individual's behaviour, and is derived largely from previous experience.
Self-efficacy	This refers to the level of a person's confidence in his or her ability to successfully perform a set behaviour. Self-efficacy is influenced by a person's specific skill capabilities (and other individual factors), as well as by environmental factors (barriers and facilitators).
Social Support	This refers to the instrumental, informational, or emotional support provided by family, friends or significant others [476]

Self-efficacy is fundamental to Social Cognitive Theory [73, 474, 475] and is believed to directly and indirectly influence motivation, affect and behaviour in children and adolescents [73, 475, 477]. Self-efficacy beliefs are cognitions that determine whether health behaviour change will be initiated, how much effort will be given to the task and how persistent an individual will be in sustaining this effort despite setbacks and failures [73, 475]. Additionally, high self-efficacy in a specific domain is thought to motivate an individual to attempt a given behaviour, and successful performances of the selected behaviour further enhances self-efficacy (e.g., physical activity) [475]. According to Bandura [474], an individual's self-efficacy beliefs are formed by past experiences, vicarious learning, verbal persuasion, and interpretation of one's physiological state [474]. Moreover, self-efficacy beliefs can affect physical activity indirectly by influencing self-management skills (e.g., goal setting, self-persuasion, planning, and problem solving) and perceptions about socio-cultural environments that present barriers or, conversely, provide support for physical activity [473, 478, 479]. This relationship is displayed in Bandura's (2004) model [479] (see Figure 3.3 below). The literature supports self-efficacy as an important determinant of physical activity [480, 481] and interventions that build self-efficacy in children and adolescents via frequent and pleasurable experiences with physical activity, are critical for increasing children's self-efficacy [475, 480, 482-486].

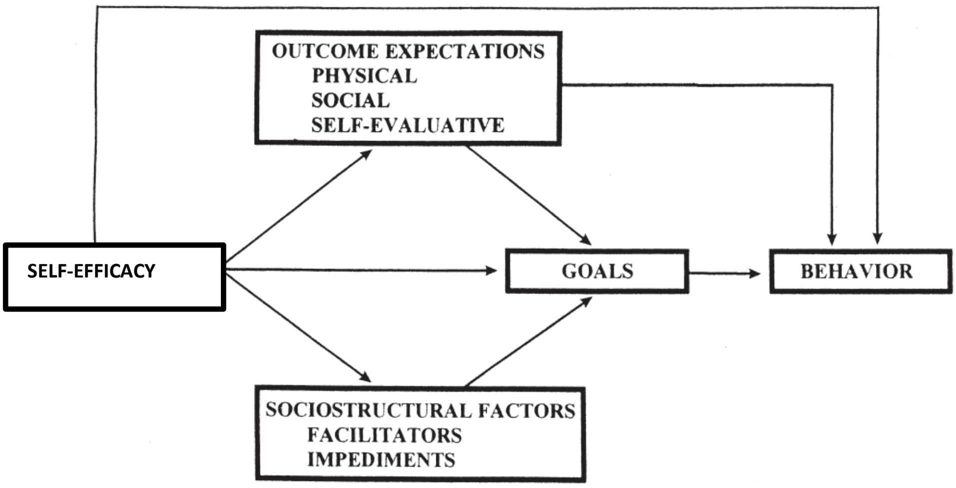

Figure 3.3: Bandura's structural paths of influence on health-promoting behaviour [479]

Self-efficacy for physical activity has also shown to be highly correlated with vigorous physical activity among both boys and girls [487-491]. These findings suggest that self-efficacy beliefs and perceptions of exertion need to be considered in the context of improving physical activity participation – especially in intense or vigorous activities (e.g., fitness programs). This is even more important as children move into adolescence, as older children have been shown to rate perceived exertion significantly higher than younger children (despite a standardized exercise workload) [492], potentially influencing their willingness to participate in high intensity physical activity. Self-efficacy research suggests that participation in vigorous physical activity programs can be maximized by including individually tailored mastery experiences compatible with the fitness and skill level of the child and by decreasing uncomfortable perceptions of exertion during exercise by encouraging enjoyable activities at appropriate levels of effort [486].

Similarly, physical activity self-efficacy has been shown to have a reciprocal relationship with perceptions of social support for physical activity, and might influence physical activity indirectly through perceived barriers and self-management [493]. Whether this relationship identifies self-efficacy and perceived social support as moderators [494] or mediators [495] of physical activity, behaviour change is not clear [71, 473]. However, the techniques that have been shown to significantly improve physical activity self-efficacy, and therefore physical activity behaviours, include goal setting and action planning, positive reinforcement for effort or progress towards a set behaviour, the provision of instruction and feedback on performance, self-monitoring, the provision of information on consequences of behaviour and skills practice [481]. Consequently, programs that develop these skills may directly or indirectly effect physical activity behaviours through changes in self-efficacy.

The influence of perceived social support on physical activity behaviour in children and adolescents is also supported in Social Cognitive Theory [479]. Studies have found that social factors, such as support for physical activity from family [471, 496-501] or friends [502], is important for sustaining physical activity (and vigorous physical activity) in children and adolescents [487, 503]. While less is known regarding the role of the teacher in providing social support for physical activity in children, the family and home environment have been found to affect children's physical activity in a number of ways [504]. Parents have been shown to influence their children's physical activity behaviours through direct modelling, rewarding desirable behaviours and punishing or ignoring undesirable behaviours, establishing or eliminating barriers and rules, providing resources to perform the behaviour, social routines, and employing authoritative parenting procedures to help the child develop self-control skills [505, 506]. Similarly, other family members have been shown to influence children's physical activity through role modelling and social support [471, 504].

Researchers have suggested that combining social support, self-efficacy, and positive learning experiences in physical activity interventions to increase physical activity both in and out of school, is an effective strategy to improve health behaviours in children and adolescents [486]. In addition, given that self-efficacy beliefs have been shown to remain relatively stable during secondary school [494], and that children's self-efficacy about overcoming barriers to physical activity is mainly formed during primary school, Dishman et al. (2010) suggest that physical activity interventions to enhance self-efficacy are needed before adolescence [473].

3.5.2 Competence Motivation Theory

Harter's (1982) Competence Motivation Theory is another conceptual framework that has been used to understand the factors that motivate children to participate in sport and physical activity [372]. In Harter's model (Figure 3.4), perceived competence is the key determinant of physical activity behaviour, where perceived competence refers to individuals' judgement about their ability in a particular physical domain [372]. Harter proposes that children and adolescents make judgements about their physical activity based on outcomes (e.g., trophies, scores, winning), social sources (e.g., feedback and reinforcement from parents, teachers, and coaches), and internal sources (e.g., self-referencing) [372]. As the individual moves through childhood into adolescence, the sources of information used to construct perceptions of competence have been shown to vary, and it is the identification and implementation of strategies to maximize competence motivation that is thought to increase physical activity behaviours [372]. Research has shown that children (ages 5–9 yrs.) are inclined to use mastery of simple tasks, level of effort, and feedback from parents to judge physical ability, and adolescents (ages 10–15 yrs.) tend to use performance outcomes relative to their peers and verbal and non-verbal feedback from teachers and coaches to judge physical ability [477]. Considerable evidence also shows that children and adolescents who report stronger beliefs about their physical competencies are more likely to enjoy physical activity and sustain interest in continuing involvement, and that greater enjoyment further enhances a child's motivation to be physically active [477, 507]. Therefore, enhancing children's perceived and actual physical competence should be a priority for researchers interested in facilitating physical activity in children and adolescents [508]. It has been recommended that creating an environment that enhances children's perceived competence, and helping children develop self-regulation skills (e.g., goal setting), will translate to greater enjoyment, self-esteem, motivation, and physical activity behaviour [435].

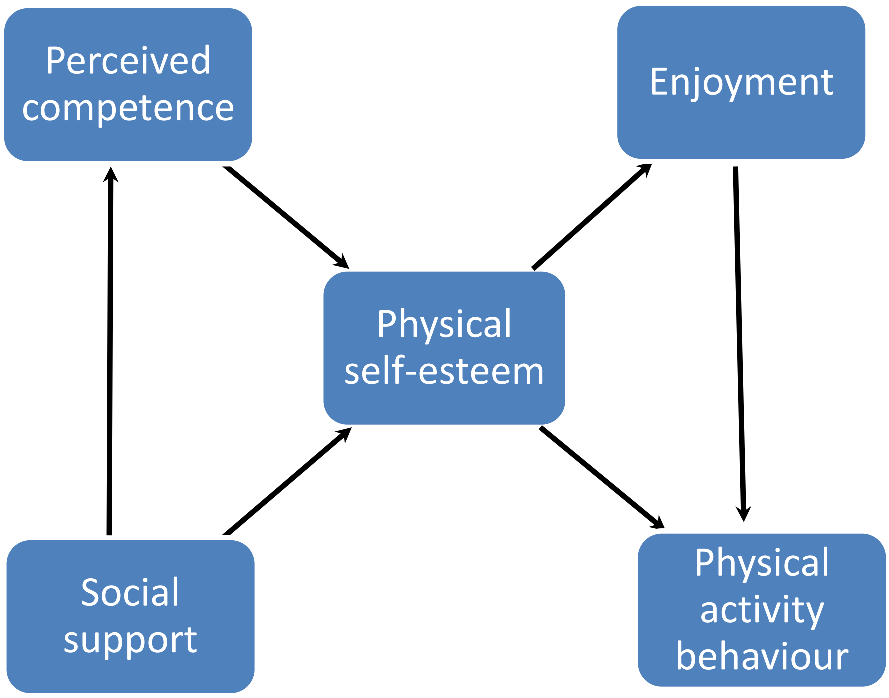

Figure 3.4: Harter's Competence Motivation Theory Model (adapted for the physical domain by Weiss 2000 [435])

Enjoyment is a key reason that children and adolescents initiate and continue to participate in physical activity, while lack of fun or enjoyment is likely to lead them to withdraw [462, 509]. Strong positive relationships between physical activity and enjoyment have been shown to exist in children, where measures of enjoyment have consistently predicted physical activity participation in children [510]. Dishman et al. (2005) [511], demonstrated that enjoyment mediated the effects of a school-based physical activity intervention in adolescent girls, and enjoyment has also been linked to various physical activity correlates, such as self-efficacy, goal setting, and perceived competence [512, 513]. In support of the evidence regarding physical activity enjoyment, the World Health Organisation has stressed the importance of physical education being enjoyable and appealing for children and adolescents and recommended the development and use of specific teaching strategies to facilitate this [23].

Some studies have targeted enjoyment as a critical component in physical activity interventions but there is limited literature identifying specific program components that make physical activity enjoyable for children and adolescents [23, 58, 471, 514]. The World Health Organisation (2012) recommends that: children and adolescents have access to a range of physical activities where the physical environment, equipment and facilities are of good quality; the activities be enjoyable (fun), affordable and preferably outdoors; that opportunities for social interaction, competition and skill development are present; and that physical activity is combined with education about health benefits [23, 515]. Research supports the notion that the social environment influences how enjoyable the physical activity environment is perceived by children and adolescents, with many children and adolescents identifying the social environment (including: opportunities to meet new people, make friends and develop social skills, cooperation, integration, positive attitudes, team spirit and communication) as a major determinant of activity engagement [23, 515-517]. Given the potential effect that enjoyment may have on physical activity participation, it is recommended that physical activity interventions should ensure enjoyment is central to learning experiences to increase participation levels and improve attitudes towards physical activity [510].

3.5.3 Health Promoting School Framework

The Health Promoting School Framework takes into account the physical, social and emotional needs of the students and implements comprehensive and integrated programs that include the curriculum, the environment (physical and social), and community partnerships (including closer involvement with parents) [371, 518]. The goal of the World Health Organisation's Global School Health Initiative is to increase the number of schools that can truly be called 'Health-Promoting Schools', where a Health-Promoting School can be characterised as a school constantly strengthening its capacity as a healthy setting for living, learning and working [519].

In the health promoting schools framework there are three interrelated areas (see Figure 3.5):

1. *Teaching and learning curriculum*: This includes what is taught, how this is decided and the way in which teaching is delivered and learning facilitated.

2. *School environment*: This includes the school physical environment, the ethos and values promoted in the school, as well as the policies and structures developed to create an environment that is conducive to healthy living, learning and working.

3. *Partnerships and community links*: This includes internal partnerships with parents, staff and students and external partnerships with other schools, health workers, government and non-government organisations [520].

The literature identifies a number of benefits accruing from the creation of a Health Promoting School. Findings indicate health gains for primary school students will most likely occur if a well-designed program is implemented which links the curriculum with other health promoting school actions (e.g., in the playground and in the home), it contains substantial professional development for teachers and is underpinned by a theoretical model [358, 371]. Studies looking to improve the fitness levels of children may benefit from using a Health Promoting School approach.

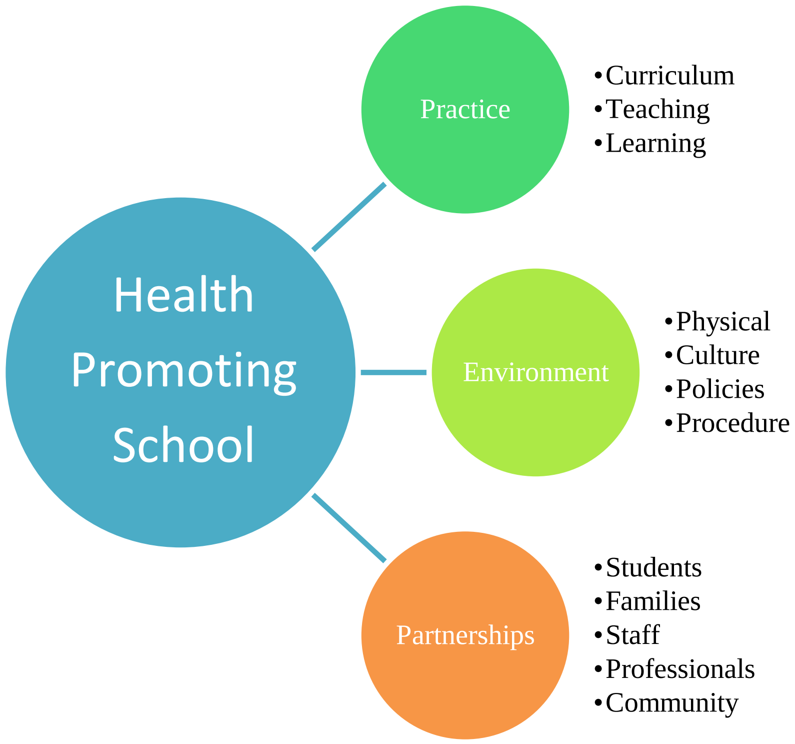

Figure 3.5: Health Promoting Schools Framework

3.5.4 Socio-Ecological Theory

Recently, many researchers have shifted their primary focus from individual-level determinants of physical activity to broader social, physical, cultural, and economic determinants of physical activity behaviour. This shift aligns with ecological approaches that acknowledge the complex interaction between an individual's behaviour and multiple levels of the environment [74]. These multiple influences (including individual, interpersonal, social environment, physical environment and policy factors) can be linked to the Socio-Ecological Model [74] (Figure 6). The social environment (e.g., parent support, peer support and support from teachers) and physical environment (e.g., access to facilities, programs and equipment) have been shown to influence children and adolescents' physical activity [460, 483, 521, 522]. These concepts also align with concepts from social–cognitive and environmental psychology and support proximal social prompts and the provision of equipment and facilities as influences on physical activity behaviour adoption and its maintenance [483]. Schools have been identified as important settings for promoting physical activity [200, 523] and evidence suggests that children's activity levels can be increased by changing aspects of the school environment. For example, access to play and sports equipment, safe areas to play, allocation of time for physical activity, the provision of quality physical education lessons, on-going social support from parents, teachers and peers [383, 408, 524].

The school environment is an emerging area of great interest to physical activity researchers, given that recess and lunch breaks provide an ideal opportunity for promoting physical activity in the school setting [45, 525, 526]. Students' perception of the school's physical environment, has been shown to directly relate to their satisfaction with those environments, and student satisfaction is directly related to more active behaviour [527, 528]. The limited data available highlights that specific components of a school playground act as facilitators of physical activity (e.g., grassed areas to play, access to equipment and facilities) [395, 529], and that most students enjoy active games and spending recess in the playground [526]. However, several barriers also hinder physical activity participation in the school playground, with many students reporting that their play areas are too small and lack physical activity opportunities (e.g., sport and games equipment, fixed playground equipment, coloured bitumen markings, grassed areas) [45, 210, 530].

There are distinct differences between the perceptions of primary school students and those of secondary school students in relation to the school environment and its relationship to physical activity [45]. Hyndman, Telford, Finch and Benson (2012) found that outcome goals such as 'having fun' and 'enjoyment', as well as interacting with peers, were perceived to facilitate children being physically active, and recommended that future interventions target 'enjoyment' or the inclusion of 'fun' physical activities with friends during recess and lunch [45]. Awareness of the environmental factors that facilitate physical activity during recess and lunch would greatly benefit the design, implementation and evaluation of physical activity interventions for children and adolescents.

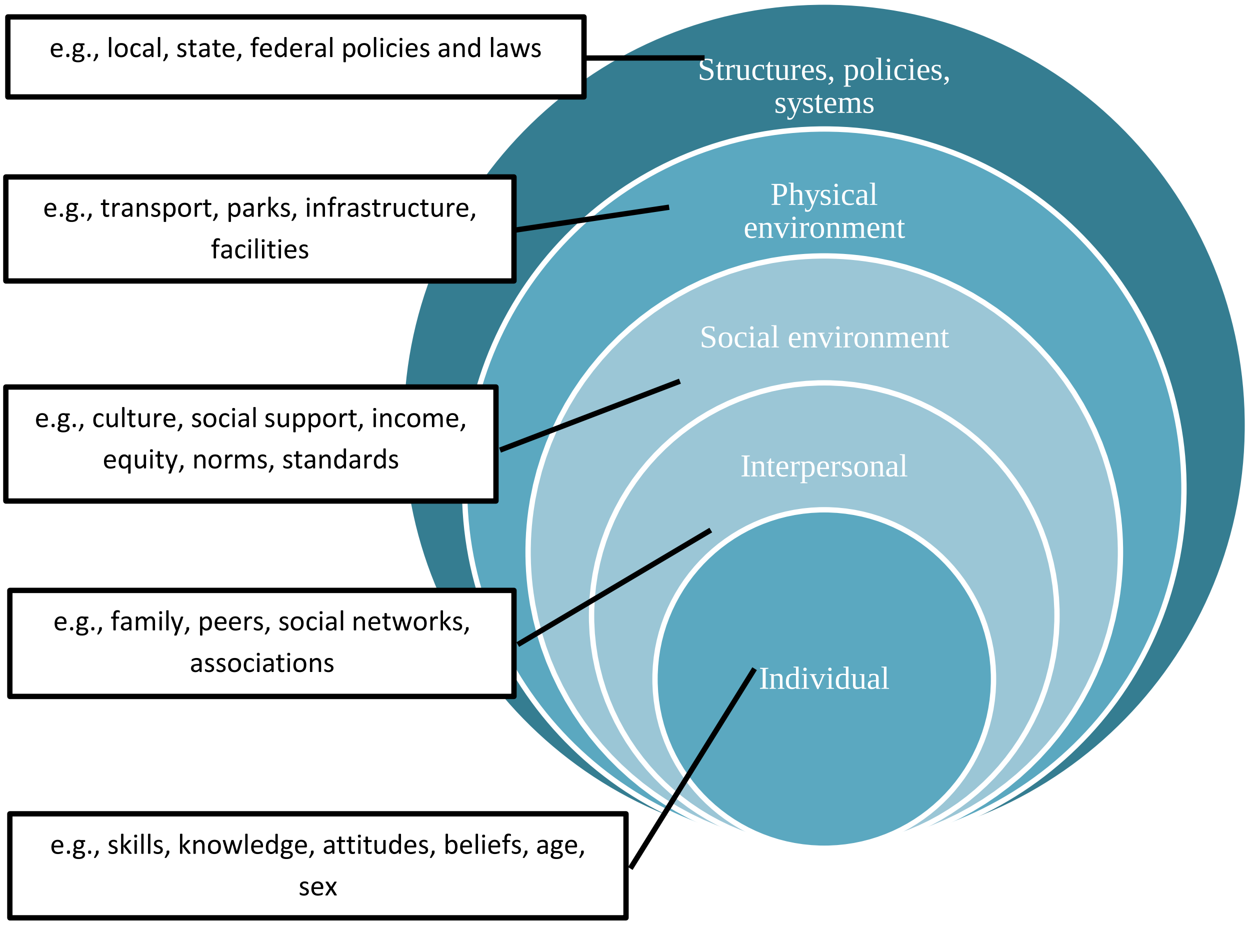

Figure 3.6: Levels of influence in the Socio-Ecological Model

3.6 Conclusions

Behavioural theories can be applied in explaining why children and adolescents initiate and maintain physical activity behaviours, and can be used to inform intervention design, delivery and evaluation. Although previous physical activity and physical fitness interventions have shown varied levels of success [50] there have been limited theory-driven, multi-component, school-based programs that educate children and adolescents about the benefits of achieving and/or maintaining high levels of fitness and engage them in enjoyable physical activities (specifically designed to improve physical activity intensity and physical fitness levels).

The quality and quantity of intervention studies targeting physical activity in children have improved in recent times, but methodological limitations are present in many of these studies. Few studies have specifically applied behaviour change theories to school-based physical fitness interventions (rather than physical activity alone) or evaluated the effectiveness of targeting theoretical constructs for initiating and sustaining physical activity behaviour changes (i.e., via mediation analysis). There are no studies that take a multi-component approach to improving physical activity and fitness by targeting the school curriculum, the school environment, recess and lunch breaks at school, and the home environment by means of specific program components – areas that have shown promise for initiating changes in physical activity and physical fitness levels [380]. Moreover, it has been suggested that primary school children may benefit from the provision of game ideas and instructions, and that increased encouragement for children to participate in games and physical activities via social support, is paramount for the enhancement of physical activity and fitness in the school setting [194, 531], yet such initiatives are lacking in Australian schools and internationally.

Chapter Four

Feasibility and preliminary efficacy of the Fit-4-Fun intervention for improving physical fitness in a sample of primary school children: A pilot study

This paper describes the feasibility and preliminary efficacy of the Fit-4-Fun intervention for improving health-related fitness and increasing physical activity in primary school-aged children. The unique program proved to be efficacious for significantly improving muscular fitness and flexibility. Changes in physical activity and all other fitness outcomes were in the hypothesized direction but were not statistically significant. The multi-faceted approach to facilitating physical activity behaviour change, targeting improvements in health-related fitness using enjoyable activities for children, and extending the educative components of the program beyond the classroom using the Health Promoting School Framework proved to positively influence both physical activity and health-related fitness measures. A detailed process evaluation suggested that the program was feasible for use in the primary school setting.

This chapter addresses two research questions:

- What is the effect of a school-based intervention (Fit-4-Fun Program) on the health-related fitness and physical activity levels of primary school-aged children?
- What is the feasibility of the Fit-4-Fun Program for improving physical activity and health-related fitness as a curriculum-based Health and Physical Education program in the primary school setting (using measures of adherence, retention, recruitment and satisfaction)?

Eather, N., Morgan, P.J., Lubans, D.R., 2012. Feasibility and preliminary efficacy of the Fit-4-Fun intervention for improving physical fitness in a sample of primary school children: a pilot study. *Physical Education & Sports Pedagogy*, 18:4, 389–411. (IF 2.34) (See Appendix 4 for published version.)

4.1 Abstract

Objective

The primary objective of this study was to evaluate the feasibility and preliminary efficacy of a school-based physical fitness intervention (Fit-4-Fun) on the physical fitness and physical activity levels of primary school children.

Methods

A group randomized controlled trial with a three-month wait-list control group was conducted in two primary schools in the Hunter Region, NSW, Australia. Participants (n = 48 students; mean age 10.9 years ± 0.7) were randomized by school into the Fit-4-Fun intervention (n = 32 students) or the control (n = 17) conditions. Fit-4-Fun was an eight-week program that included: 8 x 60 min Health and Physical Education (HPE) lessons, a break-time activity program (recess and lunch) and a home fitness program. The control group participated in their usual weekly 60 min HPE lessons. Assessments were taken at baseline and post-intervention (eight-week) to determine changes in health-related fitness (HRF) levels, physical activity (PA) and attitudes towards HRF testing. Objectively measured PA (mean steps/day) was assessed using seven days of pedometry and HRF was assessed using a battery of tests including: seven-stage sit-up test, push-up test, basketball throw, wall squat, sit and reach, shoulder stretch, 20 m shuttle test, and height and weight measurements. A questionnaire was also administered to assess perceptions of physical fitness and physical fitness testing and changes in attitudes to fitness testing. Intervention effects were assessed using analysis of covariance (ANCOVA) and Cohen's *d* effect sizes are reported.

Results

Children in the intervention group improved in all HRF measures with significant group x time effects (p <.05) observed in the seven-stage sit-up test (d = 0.9), the sit and reach tests (right leg d = 1.0, left leg d = 0.9, both legs d = 1.1) and the wall squat tests (right leg d = 0.9, left leg d = 0.6). No significant group x time effect was found in the beep test, basketball throw, PA measure or psychological measures. The control group did not display significant within-group effects for any measure.

Conclusions

Results indicate that a multi-component HRF intervention for primary school children that targeted the three areas of a health promoting school (HPS) and incorporated social support

for participation in physical fitness activities was feasible and efficacious in improving muscular fitness and flexibility levels of children.

Key words: Health-related physical fitness, intervention, children, school.

Trial Registration: Australian New Zealand Clinical Trials Registry No: ACTRN12610000642088.

4.2 Introduction

High levels of physical fitness in children and adolescents are associated with improved physical and mental health. Recent studies have shown that children who display high levels of physical fitness present fewer markers for Metabolic Syndrome and have a decreased risk of developing cardiovascular disease along with other chronic illnesses such as obesity, Type 2 diabetes mellitus, osteoporosis and some cancers [9, 220]. These children are also less likely to suffer from anxiety and depression [223], and more likely to perform better academically [27]. Evidence is also mounting to support the case that markers of ill-health and physical fitness behaviours in childhood, track through to adulthood – highlighting the need for the development of early interventions [28].

The components of physical fitness that have been shown to directly relate to health status are cardiorespiratory fitness, flexibility, muscular strength, muscular endurance and body composition – referred to as the health-related fitness (HRF) components [24]. Of note, are recent findings linking vigorous PA with substantial health gains and the prevention of obesity, rather than total PA [229]. It is thus plausible to suggest that improvements in all of the HRF components via programs that engage individuals in regular high intensity PA (or vigorous PA) in combination with specific stretching, and muscle and bone strengthening activities, will result in improved short and long-term health benefits [3].

The global public health issues of poor physical fitness, physical inactivity and obesity, have emerged in light of alarming health trends. Evidence shows that HRF in children and adolescents worldwide is in decline and that the decline has been most rapid in recent decades [12, 13]. Additionally, the prevalence of excess weight and obesity is reaching epidemic proportions in many countries [264]. Data from recent studies also suggest that PA levels decline with age and that there is a significant drop in PA levels among adolescents and young adults [174, 532]. These studies show that children and adolescents in many industrialised nations do not participate in sufficient PA to accrue associated health benefits, with approximately 25% of Australian children and adolescents [174] and up to 42% of boys and 21% of girls in U.S. schools not meeting the current PA recommendations [533].

In response to these new findings the U.S. Department of Health and Human Services released updated PA guidelines for children and adults that now include physical fitness parameters [303]. Previously, children were encouraged to participate in 60 min of MVPA on at least five days per week [534]. The new guidelines for children recommend MVPA for at least an hour every day with an emphasis on vigorous activity at least three days per week. They also outline that children aged 6–17 years need to perform muscle-strengthening and bone-strengthening activities on at least three days per week [303]. In light of these trends, research efforts and interventions investigating and targeting children's health may beneficially be re-directed toward activity of vigorous intensity to improve HRF.

The school, via the curriculum, school ethos and community, is an ideal setting in which to educate students about the importance of PA and the value of achieving and/or maintaining HRF standards [335]. There are numerous opportunities for the promotion of PA and for the development of essential knowledge, attitudes and skills regarding PA in the school setting. These include HPE lessons, school sport, recess and lunch breaks, before and after school care, school transport options, subject integration activities and homework activities. However, studies have questioned the quality and quantity of HPE lessons delivered in primary schools [36], noting a range of barriers (e.g., lack of training, crowded curriculum, lack of confidence and lack of interest) reported by Australian teachers in their ability to achieve important student outcomes in a range of HPE topics [65]. The broad scope of the HPE curriculum in Australia, the large array of learning objectives in this subject area in the Primary School Curriculum and the limited mandatory curriculum time allocated to HPE in many countries (60 min in Australia) also make it difficult for classroom teachers to implement programs that increase the amount and intensity of student PA, let alone create the training effects required to improve physical fitness. This may be attributed to a lack of quality physical fitness programs and resources available to schools that support the curriculum requirements and extend learning beyond the confines of the classroom [37]. Teachers have reported a desire to have access to up-to-date and expertly developed programs that not only give them ideas for quality teaching in health and PE but that also give them specific instructions and strategies on how to teach a variety of health and PE topics and to facilitate the learning of essential knowledge and skills required to lead a healthy lifestyle [65]. Quality HPE lessons are important for physical fitness promotion, as essential skills learned during this time form the foundation for future behaviours in the wider school community [40].

A small number of researchers have explored HRF in children resulting in a number of primary school interventions being implemented and evaluated in the U.S., Europe and New Zealand. Interventions such as CATCH [436], KISS [437] and SPARK [431], along with a few small-scale HRF programs [438-442], have demonstrated some positive results in improving HRF. However, many of these interventions exhibit limitations in their study design and methodology and may be limited by a failure to address the multiple components that influence behaviour in the school setting and a lack of reference to credible learning theories or curriculum direction in intervention designs. In addition, many of the programs do not specifically target improvements in all of the HRF components [380] or provide multi-component programs to extend learning into the school playground and the home, potentially limiting the impact that the program has on health outcomes and behaviour change. The Cochrane Review of school-based PA programs [380] identified only 11 studies of 104 conducted in schools that reported intervention effects on physical fitness in primary school-aged children, with 10 reporting BMI results (a measure of body composition), only one reporting VO_2max. results (a measure of cardiorespiratory fitness) and no studies identifying muscular fitness outcomes [380]. It is clear that a well-designed HRF program that is not only based on the HPE curriculum, but is grounded in credible learning theory, targets all facets of a HPS (curriculum, school environment, home) and specifically targets improvements in HRF is needed.

Fit-4-Fun is an innovative and engaging school-based physical fitness education program. It encompasses all of the components of the HPS [48], extends learning beyond the classroom and provides professionally designed curriculum resources for primary school teachers. The program also aims to promote the development and maintenance of positive PA and HRF behaviours and attitudes among participants, by identifying and addressing possible mediators of behaviour change (e.g., social support, self-efficacy, supportive environment, enjoyment) based on credible learning theories [47, 73]. This pilot study was designed to assess the feasibility and efficacy of the Fit-4-Fun intervention for improving the HRF and PA levels of children, along with their attitudes towards physical fitness. Feasibility trials and efficacy trials (also called explanatory trials) are often used to determine whether an intervention produces the intended effect under ideal circumstances [535] and are important references for describing the initial value of a program and its potential for further large-scale implementation and dissemination.

4.3 Methods / Design

Recruitment & study participants

Ethics approval for the study was obtained from the University of Newcastle, NSW, Australia (Appendix 5) and the Newcastle-Maitland Catholic Schools Office (Appendix 6). Two primary schools from the Hunter Region in NSW, Australia, were invited to participate in the Fit-4-Fun program in March, 2010, and the Principals from both schools provided informed consent. Participants were sought from Stage 3 classes (Grades 5 and 6) with all students being eligible to participate in the program if they had returned a signed informed consent letter from their parents with child assent, and did not currently have a medical condition or physical injury preventing testing or training. A total of 56 study information packages (Appendix 7) were distributed during the two-month recruitment period with a consent rate of 85.7%.

There were 48 participants from the two schools with ages ranging between 10–12 years (mean age 10.9 years ± 0.7). There were 19 boys (39.6%) and 29 girls (60.4%) participating in the study with the majority of the participants having been born in Australia (97.8%) and spoke English at home (97.8%). The intervention group consisted of 31 participants (20 females, 11 males). The control group consisted of 17 participants (8 males, 9 females). All participants were blinded to treatment conditions during baseline assessments (Figure 4.1).

Study design

The feasibility study involved a group randomized controlled trial (RCT) and the two schools were randomly assigned to the Fit-4-Fun intervention or a three-month wait-list control group. Randomization by school was performed after baseline assessments in May, 2010. A randomization envelope was prepared by a member of the research team and an independent third party blindly allocated the two schools into one of the two treatment conditions. Follow-up assessments were conducted in July, 2010.

Treatments

a) Intervention

Theoretical framework: The Fit-4-Fun Program was based on Bandura's Social Cognitive Theory and Harter's Competence Motivation Theory and aimed to provide children with the knowledge and skills necessary for short and long-term behaviour change [47, 536]. Positive reinforcement and social support from teachers, fellow students and parents supported participation in vigorous PA of sufficient intensity to improve HRF. The Fit-4-Fun was a multi-faceted HRF program using engaging and enjoyable activities to help children develop a range of skills (such as self-regulation, goal setting and self-monitoring) and improve their self - efficacy to perform fitness activities. An overview of the Fit-4-Fun program content and alignment with theoretical constructs is reported in Table 4.1.

The Fit-4-Fun Program included three major components that were based on the HPS Framework [48]:

Curriculum program (Appendix 8): An eight-week x 60 min HPE program was delivered during normal HPE lesson time and was developed from the NSW K-6 syllabus [537]. The program was designed to improve the knowledge, skills and understanding of students in relation to HRF and also focused on developing skills in assessing and monitoring HRF components. The program was delivered by a member of the research team (NE) who was an experienced physical educator.

Family partnership (Appendix 9)*:* Children, their parents and family members were given an eight-week home activity program designed to improve HRF levels using a range of engaging and enjoyable fitness activities, small-sided games and fitness challenges (4 x 20 min per week for eight weeks). Children were able to select from a wide range of activities that were specifically designed to improve muscular fitness, flexibility and cardiorespiratory fitness. There were also goal setting activities and reflection tasks for students to complete with their parents at the end of each week, enabling them to set personal fitness goals, monitor their achievement and to reflect on their progress.

School environment (Appendix 10)*:* Schools were provided with activity task cards outlining the rules and organisation of a range of fun and vigorous games (e.g., small-sided invasion games, skipping challenges) and a variety of equipment for use during break-times. The break-time activities were optional for students and involved enjoyable games, activities and fitness challenges.

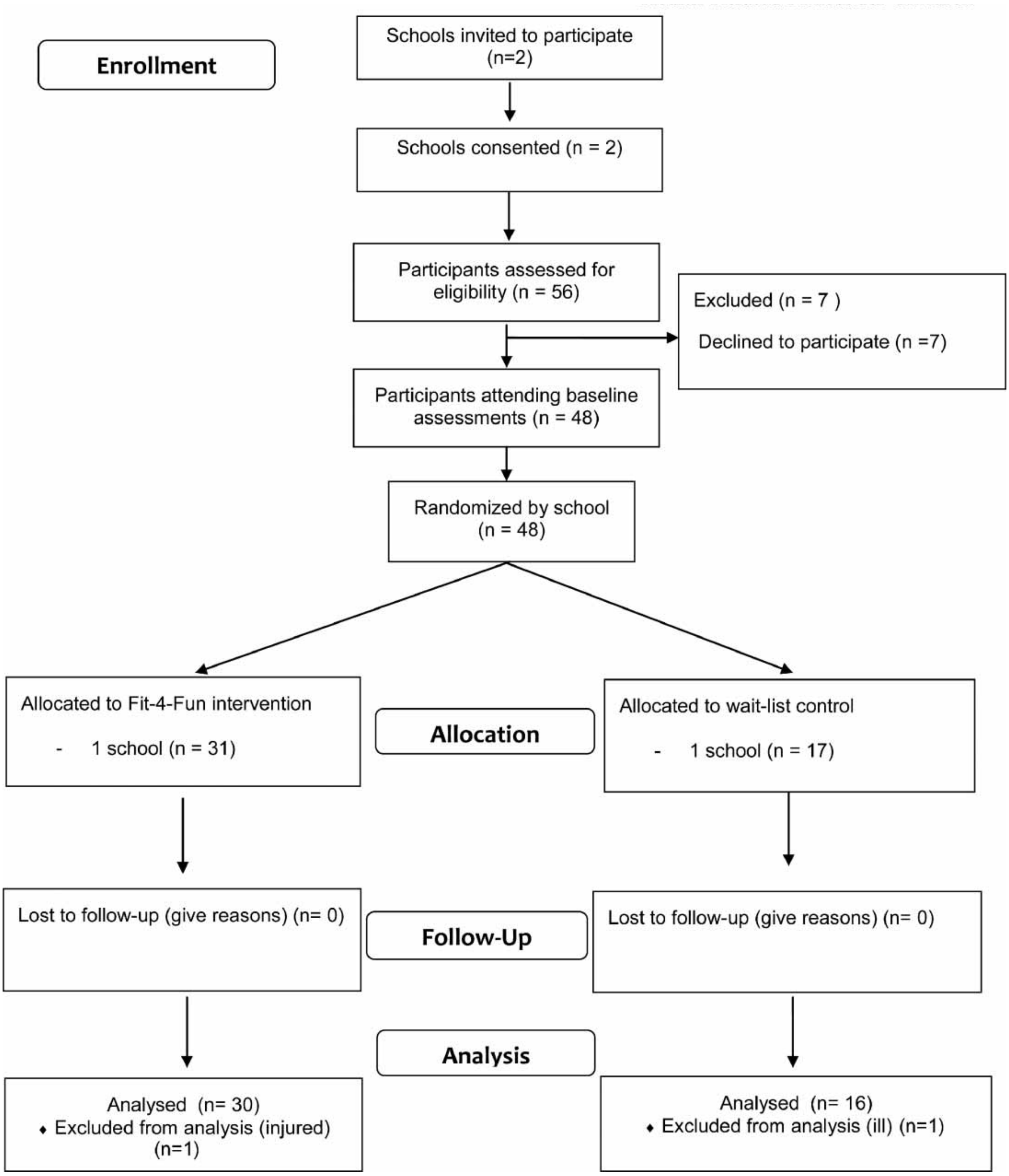

Figure 4.1: Flow of participants through the Fit-4-Fun study (Australia, 2010)

Table 4.1: 'Fit-4-Fun' program content and alignment with theoretical constructs

Wk	Session focus	Session overview	Behaviour change strategies	SCT/CMT construct
1	Health-related fitness (theory)	• Program rationale • Defining PA & PF • HRF & SRF • PA guidelines • Analysing current PA & PF behaviours • Overview of 'Home Activity Program'	• Provide information about PA & PF behaviours/link to health • Develop self-monitoring skills (weekly PA timetable, talk test) • Provide social support and encouragement (to meet PA guidelines) • Develop goal setting skills (HW task)	• Outcome expectations • Social support (home & school) • Self-efficacy • Intentions • Motivation
2	Cardiorespiratory fitness (CRF) (theory)	• Provide information on CRF • Role of heart & lungs during PA • Linking heart rate (HR) to PA intensity (lab) • Linking CRF & health	• Provide information about CRF & the role of the heart & lungs during PA • Develop skills in self-monitoring (using heart rate) • Predicting consequences of actions • Making recommendations relating to PA and CF	• Outcome expectations • Self-efficacy • Social support • Motivation
3	Improving cardiorespiratory fitness (practical)	• Revise CRF & measuring intensity using HR • Participate in a practical PE lesson with a gross motor warm-up activity, dynamic stretches, skill development activities, modified games and cool-down • HR is monitored throughout the lesson • Discussion about the type of PA and heart rate (high intensity / vigorous)	• Provide opportunity to participate in enjoyable physical activities in a supportive environment • Maximal participation is provided for and encouraged • Positive feedback is provided throughout the session • Students are to reflect on their performance and re-assess current PA behaviours	• Outcome expectations • Social support • Self-efficacy • Motivation
4	Muscular Fitness (MF) (theory)	• Define MF • Muscular strength vs. Muscular endurance • Activities that require MF • Measuring MF (lab) • Linking MF & health • Improving MF	• Provide information on MF • Link current PA behaviour to MF • Develop goal setting skills/set targets to achieve • Self-monitoring skills (PF tests) • Participation in non-threatening practical assessments (enjoyment)	• Outcome expectations • Social support • Self-efficacy • Intentions • Motivation
5	Improving muscular fitness (practical)	• Revise MF & measuring MF • Participate in a practical PE lesson with a gross motor warm-up activity, dynamic stretches, MF circuit and cool-down • HR is monitored	• Provide opportunity to participate in enjoyable physical activities in a supportive environment • Maximal participation is provided for and encouraged • Positive feedback is provided	• Outcome expectations • Social support • Self-efficacy

Wk	Session focus	Session overview	Behaviour change strategies	SCT/CMT construct
		throughout the lesson • Discussion about the type of PA and MF (resistance)	throughout the session • Students are to reflect on their performance and re-assess current PA behaviours	• Motivation
6	Flexibility (theory)	• Define flexibility • Activities that require MF • Benefits of being flexible • Types of stretching • Improving flexibility (lab) • Linking MF & health • Improving MF • Predicting outcomes from changed MF behaviours • Goal setting task • Link flexibility to lifestyle behaviours	• Provide information on flexibility • Link current PA behaviour to flexibility • Develop goal setting skills / set targets to achieve • Self-monitoring skills (PF tests) • Participation in non-threatening practical assessments (enjoyment)	• Outcome expectatio ns • Social support • Self-efficacy • Intentions • Motivation
7	Improving flexibility (practical)	• Revise flexibility and measuring flexibility • Participate in a practical PE lesson with a gross motor warm-up activity, dynamic stretches, fun stretching routines and cool-down • HR is monitored throughout the lesson • Discussion about the type of PA and improved flexibility	• Provide opportunity to participate in enjoyable physical activities in a supportive environment • Maximal participation is provided for and encouraged • Positive feedback is provided throughout the session • Students are to reflect on their performance and re-assess current PA behaviours • Link to lifelong behaviours	• Outcome expectatio ns • Social support • Self-efficacy • Motivation
8	Improving health-related fitness through games (practical)	• Revise HRF components • Revise improving HRF • Participate in a student-centred practical PE lesson where students adapt fun games to incorporate HRF • HR is monitored throughout the lesson • Discussion about the type of PA and improved HRF • Summary of health benefits with improved HRF • Evaluation of 'Fit-4-Fun'	• Provide opportunity to participate in enjoyable physical activities in a supportive environment • Maximal participation is provided for and encouraged • Positive feedback is provided throughout the session • Students learn skills in adapting PA to improve HRF • Students are to reflect on their performance and re-assess current PA behaviours • Link to lifelong behaviours	• Outcome expectatio ns • Self-efficacy • Social Support • Motivation

Wk	Session focus	Session overview	Behaviour change strategies	SCT/CMT construct
1-8	'Fit-4-Fun' Home Activities	• Participation in an 8 week home activity program • 3 weekdays: MF, flexibility, CRF activities • 1 weekday: fitness assessments • Weekends: family activities & CRF assessment • Weeks 1, 5, 8: Goal setting tasks • Problem Solving Task (assessment)	• Students participate in a range of fun activities with their parents / siblings • Family provide social support throughout the program • Students develop skills in self-monitoring and self-motivating • Students develop skills in goal setting & time management • Students develop skills in assessing & planning to improve the physical environment	• Outcome expectations • Self-efficacy • Social Support • Motivation

Abbreviations:

SCT – Social Cognitive Theory

CMT – Competence Motivation Theory

HRF – Health-Related Fitness

HR – Heart rate

CRF – Cardiorespiratory fitness

MF – Muscular fitness

PA – Physical activity

Social support for participation in all program activities was provided by teachers, parents, students and researchers throughout the intervention period. For example, students were encouraged by their teacher before they left the classroom to participate in the break-time activities, students were asked to encourage each other to participate, parents were asked via the information letter to support their child in completing the home activities and the chief researcher encouraged students to complete their home activity program during the weekly curriculum session. Teachers were also asked to regularly encourage their students to complete their home program, post notices in the classroom and on the school notice board, and to provide information and updates relating to the study at the morning assemblies, in the school newsletter and local paper. In addition an incentive scheme for student participation was in place where students accumulated stickers each week in order to gain either a gold, silver or bronze certificate at the completion of the study (Appendix 11).

Control (wait-list control group)

The control group participated in their usual 60 min/week HPE lesson over the eight-week intervention period. These lessons were practically based and consisted of a range of whole-class games and traditional sports (e.g., chasing games, soccer). The control group received the Fit-4-Fun program resources at the completion of the study period.

Outcome measures

Demographic information (age, sex, language spoken at home, country of birth) and attitudes towards physical fitness was collected via a questionnaire, and physiological data was collected using the measures detailed below.

A battery of HRF field-based assessments were conducted one week prior to intervention commencement at the start of the school day (Appendix 12). Field-based tests provide an alternative to laboratory test since they are time efficient, cheaper, require fewer resources and the tests can accommodate for multiple participants at once – ideal for the school setting [309]. The control school provided a large classroom in which to conduct all HRF tests other than the beep test, which was run on a concrete area in the school playground. The intervention school provided a large covered outdoor area where all tests were run. The testing environment was identical for both baseline and follow-up measures. All tests, other than the beep test, were performed in groups of two or three with a trained research assistant remaining with the group for all assessments. For the control school the beep test was run as a final assessment with the whole group and in two groups (sorted by class) for the intervention school. The physiological fitness tests included:

Cardio-respiratory fitness (CRF)

20 m shuttle run test (Beep test). Students were required to run back and forth between two lines, 20 m apart, within a set time limit. Running speed commenced at 8.5 km/hr and was increased by 0.5 km/hr each minute using the 20 m Shuttle Run Test cadence CD. Participants were instructed to run in straight lines, to place one foot over the 20 m line and to pace themselves according to the audio CD. The test requires maximal effort and participants are required to run until they can no longer keep up with the speed set by the tape. The level and number of shuttles within the level completed was recorded [538].

Flexibility (F)

Sit and reach test. Using standardized protocols as detailed in the FITNESSGRAM / ACTIVITYGRAM Reference Guide [539] students performed the sit and reach test on the right leg, the left leg and both legs together. Double leg scores, followed by single leg (back saver) measures were recorded. A negative score on the sit and reach indicates the participant did not reach the level of the toes and a positive score indicates that the participant reached beyond the level of the toes.

Muscular fitness (MF)

Wall squat test [540]. The participant assumed a seated position with both knees and hips at a 90° angle and shoulder width apart, with their back against the wall. The timing started when one foot was lifted off the ground and was stopped when the subject could not maintain the position and the foot was returned to the ground. After a short period of rest, the other leg was tested. Participants had their arms across their chest and were not allowed to place their hands on their thighs.

Seven- stage sit-up test [541]. Following test protocols, the participant attempted to perform one complete sit-up for each level, starting at level 1. Each level is achieved if a single sit-up is performed in the prescribed manner, without the feet coming off the floor. A second attempt was permitted if a level was not reached. The highest level sit-up correctly completed was recorded, with the highest level being 7 [541].

Basketball throw test [317]: The participant sat on the floor with their buttocks, back, shoulders and head remaining against the wall and their legs straight with feet together. An assistant placed a hoop on top of the student's toes and the participant assumed the chest pass position with elbows touching the wall. The participant performed a two-handed chest pass through the hoop and the distance from the wall to the place where the ball first contacts the ground was measured in metres (m). Each student performs two trials.

Push-up test [539]. Participants started in push up position. Keeping the back and knees straight, the subject lowered the body until there was a 90-degree angle at the elbows, with the upper arms parallel to the floor and then pushed back up. The push-ups were performed in time to a metronome set at 40 bpm and the subject would push-up on one beat and down on the next (20 push-ups per minute). The participant continued until they can do no more in rhythm. The number of complete push-ups performed was recorded.

Body composition (BC)

Height & weight [317]. Height was measured using a portable stadiometer and weight was measured using calibrated weight scales. Body Mass Index was calculated using the formulae BMI = mass (kg)/height $(m)^2$.

Physical activity (PA)

Participants were asked to wear sealed Yamax SW700 pedometers (Yamax Corporation, Kumamoto City, Japan) during their normal daily activities to measure PA for seven days (including three consecutive days and one weekend day) [542]. The participants were asked to wear the pedometers at all times other than when sleeping or when they might get wet. Teachers recorded the step counts and then reset the pedometers of participants at the start of the school day (9 a.m.) on Monday through to Friday during the assessment periods. On the weekend parents were asked to record the step count readings of their child and to reset the pedometer as close to 9 a.m. as possible. Any problems with recordings or participation in water-based activities were to be noted on the recording sheet and non-ambulatory activities were to be adjusted for on the daily step count via imputation. If imputation was required then a total of 1000 steps for 10 minutes of MVPA and 1500 steps for vigorous activity would have added to the participants step counts for the given time period [543].

Physical fitness testing experience and attitudes towards physical fitness testing

A purpose-designed questionnaire was administered to participants at baseline and 10-week follow-up to assess participants' fitness testing experience, and their thoughts and feelings about physical fitness activities and physical fitness testing, and their value in the HPE curriculum. Demographic information was also collected. The questionnaire was structured as follows:

Section A: Six demographic/background questions were used (e.g., age, sex, language)

Section B: Information relating to the child's experience with fitness testing was sought through the use of six closed-ended and semi-closed-ended questions (e.g., have you ever performed a fitness test?).

Section C: Information relating to values (six questions), self-competence (eight questions) and self-efficacy (six questions) regarding vigorous PA to develop fitness was sought through 20 questions. A structured alternative format questionnaire based on both Harter's PPCSC [47] and Fox and Corbin's PSPP [544] was used. The questions were adapted to measure physical fitness variables rather than PA (e.g., some children are fitter than other children their age or some children are not as fit as other children their age).

Section D: The scale had nine questions relating to social support for vigorous PA to develop fitness and is a modified version of a recent developed PA scale for adolescents [28]. The questions were adapted for both the age of the participants (using a five-point Likert type response format) and for a physical fitness focus. Response options ranged from 'never' through to 'always' (e.g., do members of your family participate in physical fitness activities/sport with you?).

Process evaluation

The feasibility of the program was examined using a number of measures. Measures of *recruitment* (evaluation of the recruitment process, dissemination of information and obtaining informed consent), *retention* (measure of how many students completed the program and participated in all assessments pre and post-intervention), *adherence* (evaluation of the degree to which staff and students followed the Fit-4-Fun program), and *satisfaction* (level of satisfaction and engagement in program by students, staff and parents) were used. A questionnaire was administered to determine students' perceptions of the various program components, attendance, and participation in extra-curricular activities (Appendix 13). A six-point Likert scale format was used with responses ranging from 'Strongly Disagree' through to 'Strongly Agree' (e.g., I think all schools should have the Fit-4-Fun Program). Focus group interviews involving 2–3 students and lasting 5–10 minutes were also conducted by trained research assistants to examine the perceptions of students about the Fit 4 Fun program. The groups were based on friendship groups (both single-sex and mixed-sex groups). The focus group sessions were conducted in a private place (e.g., vacant classroom, outdoor area) at the end of the physical fitness assessments and utilized standardized semi-structured questions. The anonymous verbal responses were written down by the research assistant. The following questions were asked: What did you like about the Fit-4-Fun program? What didn't you like about the Fit-4-Fun program? Did your activity levels change during the breaks at school? How? Were your parents/family interested/engaged in the home activities? How have your skills/attitudes/behaviours towards physical fitness changed over the past eight weeks? How? What changes would you make to improve the program in the future?

Statistical analysis

All analyses were conducted using the statistical software package SPSS (version 18.0). Independent sample t-tests were performed on continuous variables (e.g., age) and chi-square tests were performed on dichotomous variables (e.g., sex) for identifying key demographic outcome variables. A descriptive analysis (percentage and frequency counts) was conducted to assess retention, recruitment, adherence and satisfaction of the Fit-4-Fun intervention. Prior to analysis, normality and equal variance of the data was assessed using skewness and kurtosis criteria [545]. Univariate outliers (one for the sit & reach test and the wall squat test) were excluded from the data set where z score > ± 3 [546].

Analysis of covariance (ANCOVA) was used to evaluate the effects of the Fit-4-Fun intervention on PA, HRF levels and attitudes toward physical fitness. For all analysis, alpha levels were set at $p < 0.05$. The dependent variable was the post-test scores for HRF, PA and attitudes, treatment group was the fixed factor and baseline scores for all measures were used as covariates in the above analysis; where missing values at follow-up were calculated using intention-to-treat for the PA measures (last observed carried forward). Effect sizes (Cohen's d = intervention mean change score – control mean change score/pooled standard deviation at baseline) have also been presented in this paper given that the feasibility study is not powered to detect significant difference between groups. Effect sizes were interpreted as small (d = 0.20), medium (d = 0.50) or large (d = 0.80) [547]. Focus group responses were analysed using an inductive analysis where an initial exploration of the verbal responses was used to identify any patterns or themes [548]. Using a recursive approach, quotes with similar meanings were grouped together and labelled with a 'theme'. A concept map was then created to give a visual display of the themes and to aid in providing an accurate description and interpretation of the focus group data. Representative quotes are presented in the results.

4.4 Results

Primary outcomes: HRF and PA

The study groups did not significantly differ on any of the baseline characteristics ($p > .05$) or measures other than for age ($p < .01$) (Table 4.2). The results for both the control and intervention groups for all HRF and PA assessments are reported in Table 4.3. A significant group x time effect was exhibited for the sit & reach test (all three measures), the seven-stage sit-up test and the wall squat test (both left and right leg). Large within-group effects were found for the intervention group for flexibility (sit & reach 0.9 ≤ d ≥ 1.1) and muscular fitness (wall squat-right d = 0.9 & seven-stage sit up d = 0.9) and a medium-to-large effect was found for muscular fitness using the basketball throw test (d = 0.7). No significant group x time effects were found in the beep test, basketball throw test or PA levels. No significant improvements were found for the control group (p >.05) in any measure.

Table 4.2: Baseline demographic data of participants in the control and intervention groups (Australia, March 2010)

Characteristic	Control (n = 17)		Fit-4-Fun (n = 31)		Total (n =48)		Values	
Age	**Mean**	**(s.d.)**	**Mean**	**(s.d.)**	**Mean**	**(s.d.)**	**t**	**P value**
	11.06	.243	10.72	0.80	10.85	0.67	2.1	.043
Country of Birth	**Australia**	**other**	**Australia**	**other**	**Australia**	**other**	**χ^2**	**P value**
	17 (100%)	0	30 (96.8%)	1 (3.2%)	47 (97.9%)	1 (2.1%)	.454	.646
Language spoken at home	**English**	**other**	**English**	**other**	**English**	**other**	**χ^2**	**P value**
	17 (100%)	0	30 (96.8%)	1 (3.2%)	47 (97.9%)	1 (2.1%)	.454	.646
Sex	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**χ^2**	**P value**
	8 (47.1%)	9 (52.9%)	11(35.5%)	20 (64.5%)	19 (39.6%)	29 (60.4%)	.615	.316

Secondary outcomes

With regard to fitness testing experience, 22 (52.2%) students reported performing the beep test and less than 11% reported experience in the sit & reach test (6.5%), 1.6 km run (4.3%), shoulder stretch (2.2%), push up (10.9%), sit up (10.9%), chin up (8.7%) and height and weight measurements (4.4%). Of the students who had participated in fitness testing (n = 26) 80.8% indicated that they enjoyed the experience and 95.3% (n = 43) reported that they would like to know how fit they were. No statistically significant differences at baseline or group x time effects were found for attitudes towards fitness testing or for physical fitness related self-concept, self-esteem, values or social support from family and friends.

Process evaluation

Recruitment: Two school principals were invited to participate in the study and both agreed to participate. Out of the 56 students who were given information booklets to take home and discuss with their parents, 48 gained informed consent to participate in the study. The resulting recruitment rate was 85.7%. All 48 children were eligible and completed baseline assessments.

Retention: In relation to retention, 45 of the 48 (94%) completed all HRF assessments at follow-up. For the PA measure 43 of the 48 (90%) students recorded results for at least three consecutive days and one weekend day at baseline but only 34 out of the 48 participants adequately completed the required PA measure at follow-up (71%). There was no difference between study groups with regard to retention ($p > .05$).

Adherence: All eight curriculum sessions were presented at the intervention school with an attendance rate of 94%. Based on self-report, a total of 15 participants (47%) participated in the break time activity program on at least three occasions per week. No significant relationships were found to exist between participation in break-time activities and PA levels, or with age and sex.

Satisfaction: Scores on the evaluation survey ranged from 4.63 to 5.62 of a possible 6 for the 14 items in the evaluation survey, indicating high to very high satisfaction rates for the Fit-4-Fun program. The results revealed that students enjoyed the program (mean score = 5.5), including the practical and theory-based lessons (mean scores = 5.20 & 4.7), found the program interesting (means score = 5.23) and easy to understand (mean score = 4.63), and believed that the program should be available to all schools (mean score = 5.4). Participants were also likely to 'Agree' or 'Strongly Agree' that their knowledge and skills had improved as a result of the Fit-4-Fun Program (mean score = 5.07), their HRF and PA levels had improved (means sores = 5.62 and 5.2) and that they were likely to continue to do HRF activities in the future (mean score = 5.4). However, students reported difficulties with parent and family involvement in the home program with a mean score of 3.14 of a possible 6 for perceived parental and family involvement.

The focus group interviews revealed some common themes relating to students' opinions and attitudes about the value of the Fit-4-Fun program and supported the quantitative data. A common theme evident was that of personal gain and achievement as a result of participating. These improvements related to skill level (*'My skills have improved a lot')*, health status (*'You* *become more healthy*'), physical activity and physical fitness levels *('Made us active and got us moving', 'Getting me fit*'), attitudes toward physical fitness activities (*'I now have a positive attitude towards fitness, great respect for fitness and more likely to do it in future'*), knowledge and understanding about fitness (*'Letting us understand about fitness levels and our own fitness levels')*, and motivation for improving and maintaining physical fitness levels in the future ('*I'm more motivated', 'I love learning new exercises, enjoying myself and trying to do the best I can'*). Many responses also related to high levels of enjoyment when participating in the 'fun' activities at school and at home, as well as an appreciation of the challenges that the program presented ('*Great variety of fun activities*').

A very small number of participants expressed dissatisfaction with specific aspects of the program during the focus group interviews, and these presented in two themes. Some participants reported poor involvement by parents and family members, either via physical participation or support for the program ('*My parents had too much on and not enough time'*, *'My parents did not really encourage me to do the physical activities and did not ask me to do anything*'), and a small percentage expressed some dissatisfaction with the perceived level of effort required to perform some of the fitness tests and some of the home activities (*'Some activities were too hard – could not do them all').*

Table 4.3: Participants Health-Related Fitness scores at baseline and 10-week follow-up and ANCOVA results and effect sizes for HRF and PA measures (Australia, April – June, 2010)

Health-Related Fitness Component			Baseline		10-week follow-up		ANCOVA Results	P value	Cohen's *d*
	Study Group	N	Mean	SD	Mean	SD			
Beep Test (level)	Intervention	27	5.03	1.98	5.67	2.03	F = 1.20	.279	0.4
	Control	16	5.23	1.98	5.58	2.12			
Sit & Reach Right Leg*(m)	Intervention	29	.02	10.81	3.02	7.70	F = 7.25	.010	1.0
	Control	16	6.38	6.99	2.84	7.09			
Sit & Reach Left Leg*(m)	Intervention	29	.97	11.19	2.70	10.21	F = 7.99	.007	0.9
	Control	16	4.13	9.54	2.17	7.78			
Sit & Reach Both Legs*(m)	Intervention	29	-1.67	11.40	1.59	9.37	F = 14.38	.000	1.1
	Control	16	2.56	8.58	-0.66	8.39			
Basketball Throw Test (m)	Intervention	27	3.84	0.77	3.63	1.08	F = 1.20	.280	0.7
	Control	16	4.45	0.49	4.19	0.47			
Seven Stage Sit Up Test (level)	Intervention	27	2.15	1.40	4.13	1.09	F = 4.70	.036	0.9
	Control	16	3.13	1.41	3.94	1.69			
Push Up Test (no.)	Intervention	27	8.63	7.78	10.63	9.26	F = 0.42	.521	0.3
	Control	16	8.88	5.82	9.81	7.94			
Wall Squat Right leg (sec)**	Intervention	29	21.17	21.50	44.59	39.93	F = 8.86	.005	0.9
	Control	15	17.65	15.33	17.39	11.74			
Wall Squat Left leg (sec)**	Intervention	29	26.62	19.18	47.38	48.27	F = 8.06	.007	0.6
	Control	15	18.62	15.11	15.92	18.60			
PA baseline (mean steps/day)	Intervention	29	9923	3629	11,776	3769	F = 0.06	.803	0.2
	Control	12	11902	2558	12,550	3122			

Missing data excluded list-wise

* Outlier (z > ± 3.29) removed

** Transformed (sqr. root)

4.5 Discussion

The primary objective of this study was to determine the feasibility and preliminary efficacy of the Fit-4-Fun intervention on improving the HRF and PA levels of children. The Fit-4-Fun program was successful in improving HRF represented by medium-to-large intervention effect sizes (using Cohen's *d*) in seven of the nine measures of muscular fitness, cardiorespiratory fitness and flexibility. The feasibility of the program was also confirmed where recruitment, adherence, retention and satisfaction scores were all very positive.

The increased levels of HRF fitness, especially muscular fitness and flexibility, shown among children in the Fit-4-Fun Program demonstrates the efficacy of the 'fun' fitness-based activities and teaching strategies used in the program. The activities not only aimed to increase the amount of PA children participated in but to alter the type, duration and intensity of PA using specific HRF activities that align with the latest PA guidelines [303]. The improvements in HRF support the findings of and Faigenbaurn et al. (2009), Lubans, Sheaman and Callister (2010), Slawta and DeNeui (2010) and Matevienko and Ahrabi-Ford (2010), , who have recently demonstrated that the physical fitness levels of children and adolescents can improve using short and frequent periods of enjoyable and engaging fitness activities and that they can also improve relatively quickly [442, 549-551]. Based on effect size, our study showed greatest improvements in muscular fitness and flexibility which may be explained by the focus on these HRF components in the curriculum and home activity programs. The lack of intervention effect for the beep test (measure of cardiorespiratory fitness) and the push up test (muscular fitness) in the intervention group may have been affected by the slight, but not significant, improvements in cardiorespiratory fitness and some muscular fitness levels found in the control group over the same time period. Alternatively, the lack of intervention effects for the beep test and the push-up test, may be attributed to the short-term nature of the program, especially given that some students did not complete all the activities during the eight-week intervention period. Another explanation relates to the intensity at which the home activities or break time activities were performed. Intensity levels were not monitored during these two components of the program and participants may not have been performing the activities or games at or beyond the intensity level needed to create a training effect.

Despite being a pilot study results show that the Fit-4-Fun intervention was feasible. Recruitment for the Fit-4-Fun intervention was unproblematic with all of the invited school Principals and teachers volunteering to be involved. Literature reviewing randomized control trials have reported difficulties in the recruitment process, especially in the school-setting [552]. Retention rates were also very high with 95% of participants attending the follow-up assessment sessions. Given that there was only a small sample and that the program took a novel approach to improving HRF over a short period, involved a variety of enjoyable age-appropriate activities, was run by a qualified instructor in a supportive environment and the assessments were conducted during normal school hours,– high retention rates at follow-up would be expected. Similar successes were reported during the KISS program [407].

Adherence to the curriculum program was also excellent with 100% of curriculum sessions being delivered and a 94% attendance rate for participants. However, adherence to the break time activity program (at least three times per week) was only 47%. These results are on par with other studies incorporating a break-time program component such as the FILA Program [553] but could be attributed to the poor playground facilities at the intervention school. The school did not have a grassed area for play and the available concrete area was small and unsuitable for many vigorous group activities (especially those requiring running). This environmental confounder may have also hampered the potential success of the program to improve levels of cardiorespiratory fitness and PA. Support for this theory aligns with ecological approaches that acknowledge the complex interaction between an individual's behaviour and multiple levels of the environment [74]. Sallis and Owen (1999) and Sallis et al. (2000) noted that both variables relating to the social environment (e.g., parent support, peer support and support from teachers) and variables relating to the physical environment (e.g., access to facilities, programs and equipment) have been shown to be related to the facilitation or constraint of child and adolescent PA [460, 483]. Adherence to the home activity program also proved to be difficult for some students, especially towards the end of the eight-week period. Some students in the intervention focus groups reported participating in the home activity program for the first few weeks but then participation at home became less frequent and/or inconsistent. Lower satisfaction scores were also found for items relating to parental and family support. These results compare with previous small scale studies that reported attendance rates, where participation was higher for mandatory curriculum sessions compared to non-curricular voluntary sessions (e.g., home, lunch/recess) [553, 554]. In order for changes in behaviour to occur in children it has been shown that positive behaviours need to be supported both in the classroom, in the playground and out of the school setting [555]. Studies by Haerens et al. (2007) [556] have shown that strategies to include parents in the intervention process are imperative, especially with children and adolescents. In a recent systematic review conducted by Edwardson and Gorley (2010), the authors highlighted the need for parents to be directly involved in participating in PA in order to facilitate their child's involvement. They also suggest that parents need to encourage their child to be active, transport their child to places where they can be active, and be an active role-model for their child. Previous studies have also demonstrated difficulties in getting parents to become involved in interventions and to attend meetings regarding school-based studies [557]. To combat these anticipated barriers regarding family involvement promotion of the study was provided in the school newsletter, the parents were provided with an information package and were given a comprehensive home activity guide at the start of the program to minimize parental time demands. In this study, lack of family support may be a contributing factor for the modest improvements in cardiorespiratory fitness and PA levels, given that many of the home activities involved partner activities and challenges. The development of suitable strategies to increase participation in the non-compulsory program components and to increase parental and family participation is warranted.

Very high satisfaction levels for the Fit-4-Fun Program were reported by students in both the student questionnaire and focus groups. An average score of 5.12 of a possible 6 was recorded for all satisfaction measures on the student questionnaire. In addition, the majority of students also voiced positive attitudes and opinions about the Fit-4-Fun Program during the focus group interviews. These positive results may be credited to the 'fun' focus and novelty of the program or to the fact that participants were learning new skills and gaining valuable knowledge and understanding in an area that they were interested in. This premise is supported by the high percentage of students who wanted to know how fit they were (95.3%), who had limited exposure to fitness testing in the past, and by the many positive comments made by students regarding the value of the Fit-4-Fun Program for personal development. The measure of student attitude towards fitness testing or for physical fitness related self-concept, self-esteem, values or social support from family and friends did not change significantly over time. These results may have been affected by the short term nature of the program or a ceiling effect where high scores on all of the above measure were found at baseline. Overall, the qualitative data collected showed that the majority of students found all three components of the program valuable and enjoyable, especially the 'fun' parent and home activities, games and challenges. They also identified many skills, attributes and attitudes that they had improved as a result of participating in the Fit-4-Fun intervention – which may impact positively on self-efficacy and motivation to participate in vigorous PA and fitness-based activities in the future.

Fitness education and physical fitness testing in primary schools have been topics of much debate. In the past, fitness testing in schools frequently dominated the fitness education program or was performed in isolation, where the testing environment often invoked embarrassment and anxiety for the child [449, 558]. Fortunately, fitness testing methods used in schools to assess the different components of fitness have evolved from a performance model to a model that considers health-related outcomes [317]. Test interpretation currently employs criterion-referenced standards in contrast to the norm-referenced system of evaluation of the past [310].

These criterion-referenced standards specify the acceptable levels of fitness that are conducive to good health as opposed to performance comparisons based on the 'normal' performance results for individuals – differentiated by age and sex. There are a number of popular HRF test batteries, and variations of these, currently used in schools across nations. They include: EUROFIT, FITNESSGRAM, President's Fitness Challenge and the ACHPER Fitness Education Award [315, 317, 450]. As demonstrated by the Fit-4-Fun Program, the effective use of fitness training and assessment within a comprehensive HPE curriculum in the primary school can serve many purposes. It may help to promote individual PA, facilitate the learning of physical fitness concepts, and help children link HRF to present and future health status [449]. Fitness assessments can also enable children to evaluate their fitness levels, develop PA goals, monitor progress in achieving the recommended levels of fitness, motivate children to adopt physically active lifestyle behaviours at school and at home and provide useful information to parents [451].

Study strengths and limitations

The Fit-4-Fun intervention is a unique program that specifically targeted HRF in primary school children. It is the only program in Australia that has taken a multi-faceted approach to facilitating behaviour change via the HPS Framework, is theoretically grounded, is based on the NSW K-6 PDHPE Curriculum [537] and aims to extend HRF education beyond the classroom. The program was evaluated used a RCT and assessments were conducted by trained research assistants who were blinded to treatment allocation. In addition, fitness was assessed using validated HRF measures.

A limitation of this study is the small sample size, especially in the control group. Lower recruitment rates in this group impacted on the sample size, however, the small sample size aligned with the purpose of the study, and that was to assess the feasibility and potential efficacy of the Fit-4-Fun program for a future larger-scale implementation. School programming issues may have also affected HRF results. The changes in fitness levels in the control group could be a result of the unexpected implementation of a whole-school morning fitness program (3 x 20 min per week) by the control school during the intervention period that focused on running-based activities. The control school had a grassed play area and a covered area for play, unlike the intervention school (having only a concreted area and a covered area), and all teachers and students in the control school participated and supported this program, which research has shown to be crucial in the development and maintenance of positive PA behaviours in children [383]. Variation in the quality of instruction and social support provided by the teacher delivering the Fit-4-Fun program in the intervention group compared to the teacher delivering the HPE program in the control group may have also impacted on the results of this study. Previous studies have shown that the physical education specialists are superior to classroom teachers in delivering HPE programs [431] [559] and the difference in teaching performance may impact on participant engagement in the program. Therefore the evaluation of teacher behaviour and implementation fidelity in future research is needed. Moreover, the amount and type of support provided to children directly impacts on their ability to initiate and maintain PA behaviours [483]. Therefore, the role of teachers' encouragement to be active during the school day should be explored in future implementation of the Fit-4-Fun program.

Furthermore, the use of objectively measured PA using pedometery is a strength of this study, however it is also a limitation, as pedometers only detect ambulatory activity (and not activities such as resistance training or flexibility training) and therefore true intervention effects might not have been captured. Future studies assessing high intensity activity and non-ambulatory activities may benefit from the use of accelerometers in preference to pedometers. In terms of the control group, it is also impossible to recruit a 'true' control group in the school setting – given that Health and PE is a compulsory subject and there are 60 mins of mandatory break time available to students during each school day for 'free play.' However, conducting a randomized control trial (RCT) is considered the 'gold standard' in evaluating PA interventions and it therefore necessary to have a control group or a comparison group in order to establish the efficacy of the program.

Implications

Targeting improvements in HRF in children has emerged as an important health priority. However, few studies have specifically aimed to improve the HRF levels of children using the school setting, especially in Australia [380]. It has been suggested that HPE lessons alone do not provide the scope for improving the HRF levels of children [36, 380], however, well designed lessons have a vital role in contributing to the adoption of appropriate HRF behaviours, especially when used in combination with initiatives targeting the family [560] and the environment [561]. Therefore, future school-based programs should not only promote participation in health-enhancing PA but should take a collaborative approach which effectively involves all members of the school community (including the parents) in the education process.

4.6 Conclusions

Results indicated that a multi-component HRF intervention for primary school children that targeted the three areas of a HPS and incorporated social support for participation in physical fitness activities was feasible and efficacious in improving muscular fitness and flexibility in children. Future school-based programs should adopt more effective strategies to include and engage parents and improve the success of programs in increasing the HRF levels of children. The encouraging results of this feasibility trial will be used to refine and develop the Fit-4-Fun Program for a future larger-scale trial.

4.7 Acknowledgements

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4.8 Competing interests

The authors declare that they have no competing interests.

Chapter Five

Improving health-related fitness in children:

The Fit-4-Fun randomized controlled trial study protocol

This paper describes the rationale and methods of the Fit-4-Fun cluster randomized controlled trial for improving the physical fitness and physical activity levels of Grades 5 and 6 primary school children (second trial). The methods used in the feasibility trial (Chapter 4) were evaluated and changes were made to the Fit-4-Fun program components based on the results. The changes included reducing participation in the home activity program from four to three days per week (to reduce the burden on families), changing the wall squat assessment to the standing broad jump (studies show greater reliability and validity for use with children), encouraging teachers to increasing the amount of social support for physical activity participation, and other minor changes to the curriculum material. Details of the methodological aspects of recruitment, inclusion criteria, randomization, intervention structure and content, assessments, process evaluation and statistical analyses are described in this paper.

This chapter presents the methodology for addressing two research questions:

- What is the effect of a school-based intervention (Fit-4-Fun Program) on the health-related fitness and physical activity levels of primary school-aged children?
- What is the feasibility of the Fit-4-Fun Program for improving physical activity and health-related fitness as a curriculum-based Health and Physical Education program in the primary school setting (using measures of adherence, retention, recruitment and satisfaction)?

Eather, N., Morgan, P.J., Lubans, D.R., 2011. Improving health-related fitness in children: The Fit-4-Fun randomized controlled trial study protocol. *BMC Public Health,* 11:902. (IF=2.08) (See Appendix 14 for published version.)

5.1 Abstract

Background

Declining levels of physical fitness in children are linked to an increased risk of developing poor physical and mental health. Physical activity programs for children that involve regular high intensity physical activity, along with muscle and bone strengthening activities, have been identified by the World Health Organisation as a key strategy to reduce the escalating burden of ill health caused by non-communicable diseases. This paper reports the rationale and methods for a school-based intervention designed to improve physical fitness and physical activity levels of Grades 5 and 6 primary school children.

Methods / Design

Fit-4-Fun is an eight-week multi-component school-based physical fitness education intervention and will be evaluated using a group randomized controlled trial. Primary schools from the Hunter Region in NSW, Australia, will be invited to participate in the program in 2011 with a target sample size of 128 primary schools children (age 10–13). The Fit-4-Fun program is theoretically grounded and will be implemented applying the Health Promoting Schools framework. Students will participate in weekly curriculum-based health and physical education lessons, daily break-time physical activities during recess and lunch, and will complete an eight-week (3 x per week) home activity program with their parents and/or family members. A battery of six health-related fitness assessments, four days of pedometry-assessed physical activity and a questionnaire, will be administered at baseline, immediate post-intervention (two-months) and at six-months (from baseline) to determine intervention effects. Details of the methodological aspects of recruitment, inclusion criteria, randomization, intervention program, assessments, process evaluation and statistical analyses are described.

Discussion

The Fit-4-Fun program is an innovative school-based intervention targeting fitness improvements in primary school children. The program will involve a range of evidence-based behaviour change strategies to promote and support physical activity of adequate intensity, duration and type, needed to improve health-related fitness.

Trial Registration No: ACTRN12611000976987

5.2 Background

The fitness levels of children and adolescence are in decline [12-14]. This is an alarming trend given that high levels of physical fitness in this age group are associated with improved physical and mental health both in the short- and long-term [9, 25]. Recent studies have shown that children who display high levels of physical fitness, especially health-related fitness (HRF) [24], have a decreased risk of developing cardiovascular disease and other chronic illnesses (such as obesity, Type 2 diabetes mellitus, osteoporosis and some cancers) [562], are less likely to suffer from anxiety and depression [26], and more likely to perform better academically [27].

In response to the declining physical activity (PA) and physical fitness (PF) levels of children, and the corresponding increase in non-communicable diseases (NCD), the World Health Organization (WHO) published the Global Recommendations on Physical Activity and Health [29]. These recommendations address the link between the frequency, duration, intensity, type and total amount of physical activity needed for preventing NCD [29]. The WHO recommendations now outline that children aged 6–17 years should participate in at least 60 min of MVPA every day, and to perform vigorous PA (high intensity), muscle-strengthening PAs and bone-strengthening PAs, on at least three days per week [29]. As such, studies investigating and targeting children's health may also benefit from a redirected focus on regular vigorous intensity PA and improvements in HRF to improve overall health.

A recent review confirms that there is great public health potential for school-based interventions to improve the PA and PF levels of children and adolescents [49]. The school, via the curriculum, school ethos and community, is an ideal avenue for accessing and educating children and adolescents about the importance of PA, the value of achieving and/or maintaining HRF standards and for building the skills necessary for long-term behaviour change [335]. There are numerous opportunities in the school setting for the promotion of PA, including health and physical education (HPE), active transportation, active breaks, sport etc. While HPE is widely acknowledged the cornerstone of a schools' physical activity program, studies have questioned the quality and quantity of HPE lessons delivered in primary schools [36-38].

Recent studies have demonstrated positive results in improving HRF, especially cardio-respiratory fitness, via school-based interventions [49]. However, many have failed to address the multiple components that influence behaviour in the school setting, make reference to credible learning theories or curriculum direction in intervention designs, or specifically target improvements in all of the HRF components [380]. In addition, few studies have designed and tested multi-component programs to extend learning into the school playground and the home – potentially limiting the impact that the program has on health outcomes and behaviour change [380].

The Fit-4-Fun program is an innovative and engaging school-based physical fitness education program. It encompasses all of the components of a Health Promoting School [48], extends learning beyond the classroom and provides professionally designed curriculum resources for primary school teachers. This study builds upon the Fit-4-Fun pilot study (conducted in 2010) and will provide further evidence to support the effectiveness of the Fit-4-Fun intervention for improving the HRF and PA levels of children, along with their attitudes towards physical fitness. This paper provides the rationale and study protocol of the Fit-4-Fun program.

5.3 Methods / Design

Study design

Fit-4-Fun is an eight-week multi-component school-based HRF education intervention and will be evaluated using a group randomized controlled trial (RCT) with six-month follow-up. Ethics approval for the study was obtained from the University of Newcastle, NSW, Australia and the Newcastle-Maitland Catholic Schools Office, and is registered with the Australian and New Zealand Clinical Trials Registry (ACTRN12611000976987).

Following the initial recruitment process, all eligible participants will complete baseline assessments and follow-up measures will be conducted immediate post-intervention and at six-months. The design, conduct and reporting of the Fit-4-Fun intervention will adhere to the Consolidation Standards of Reporting Trials (CONSORT) guidelines [76]. School Principals, teachers, parents and study participants will provide written informed consent.

Recruitment & study participants

Primary schools from the Hunter Region in NSW, Australia, will be invited to participate in the Fit-4-Fun program in 2011. Initially, school Principals will be contacted via email and then a face-to-face meeting will be arranged. Written consent will be sought from both the Principal and the classroom teachers of each school before participants from Stage 3 classes (Grades 5 and 6) are recruited. All students are eligible to participate in the program if they return a signed informed consent letter from their parent(s) with child assent, and do not currently have a medical condition or physical injury preventing testing or training. Figure 5.1 depicts the proposed flow of participants through the trial.

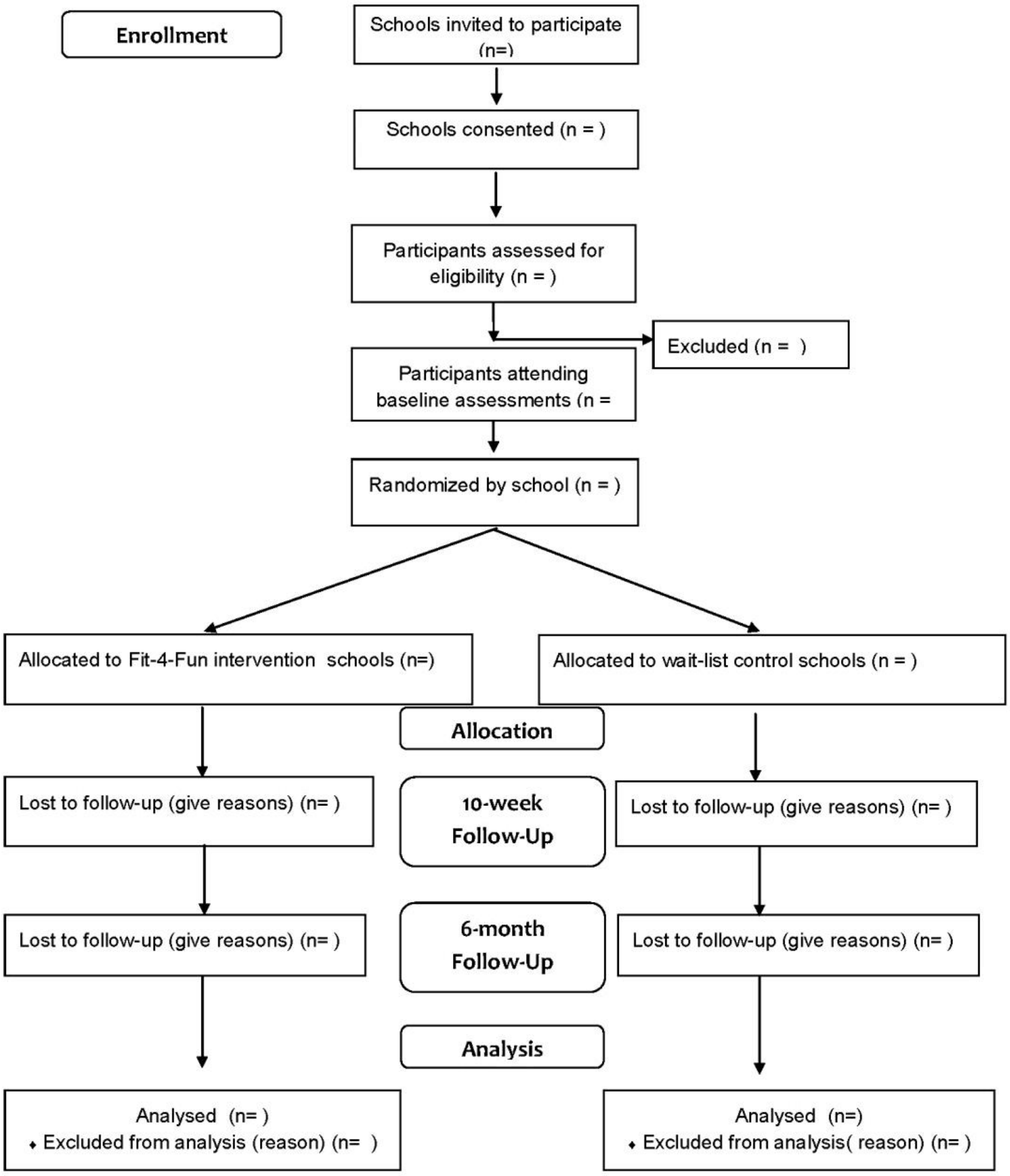

Figure 5.1: Flow of participants through the Fit-4-Fun

Sample Size Calculation

A battery of fitness assessments will be conducted to determine the HRF levels of participants. The primary outcome variable in this study is cardiorespiratory fitness. A power calculation was conducted to determine the sample size necessary to detect changes in cardiorespiratory fitness (VO_2max). Based on a previous study by Kolle et al. (2009), an increase of 6 mL/kg/min was regarded as clinically important and achievable in children [563]. Using an alpha of 0.05 and power of 80%, a sample size of 128 will be needed to detect a 6 mL/kg/min difference between groups. To account for the clustered nature of the data and participant drop-out, we will aim to recruit 200 participants from four schools.

Blinding & Randomization

Participants and research assistants will be blinded to treatment conditions during baseline assessments. Randomization by school will be performed at the completion of baseline assessments and the four participating schools will be randomly assigned to the Fit-4-Fun intervention (two schools) or a nine-month wait-list control group (two schools). A randomization envelope will be prepared by a member of the research team and an independent third party will blindly allocate the four schools into one of the two treatment conditions.

Training

Research assistants will conduct and record all physiological assessments, and will administer the student questionnaire. All research assistants will complete an identical training session prior to assessments to maintain consistency and where possible the same assessors will be used for all assessments.

Treatments

a) Intervention

Theoretical framework: The Fit-4-Fun Program is grounded in Bandura's Social Cognitive Theory and Harter's Competence Motivation Theory and aims to provide children with the knowledge and skills necessary for short- and long-term behaviour change [536, 564]. The program also aims to promote the development and maintenance of positive PA behaviours and attitudes among participants, by targeting possible mediators of behaviour change (e.g., social support, self-efficacy, supportive environment, enjoyment) [73, 564]. An overview of the Fit-4-Fun program content and alignment with theoretical constructs is reported in Table 5.1.

Table 5.1: 'Fit-4-Fun' program content and alignment with theoretical constructs

Session focus	Session overview	Behaviour change strategies	SCT/CMT construct
Week 1 Health-related fitness (theory)	• Program rationale • Defining PA & PF • HRF & SRF • PA guidelines • Analysing current PA & PF behaviours • Overview of 'Home Activity Program'	• Provide information about PA & PF behaviours/link to health • Develop self-monitoring skills (weekly PA timetable, talk test) • Provide social support and encouragement (to meet PA guidelines) • Develop goal setting skills (HW)	• Outcome expectations • Social support (home & school) • Self-efficacy • Intentions • Motivation
Week 2 Cardio-respirator y fitness (CRF) (theory)	• Provide information on CRF • Role of heart & lungs during PA • Linking heart rate (HR) to PA intensity (lab) • Linking CRF & health	• Provide information about CRF & the role of the heart & lungs during PA • Develop skills in self-monitoring (using heart rate) • Predicting consequences of actions • Making recommendations relating to PA and CF	• Outcome expectations • Self-efficacy • Social support • Motivation
Week 3 Improving cardio-respirator y fitness (practical)	• Revise CRF & measuring intensity using HR • Participate in a practical PE lesson with a gross motor warm-up activity, dynamic stretches, skill development activities, modified games and cool-down • HR is monitored throughout the lesson • Discussion about the type of PA and heart rate (high intensity/vigorous)	• Provide opportunity to participate in enjoyable physical activities in a supportive environment • Maximal participation is provided for and encouraged • Positive feedback is provided throughout the session • Students are to reflect on their performance and re-assess current PA behaviours	• Outcome expectations • Social support • Self-efficacy • Motivation
Week 4 Muscular Fitness (MF) (theory)	• Define MF • Muscular strength vs. Muscular endurance • Activities that require MF • Measuring MF (lab) • Linking MF & health • Improving MF	• Provide information on MF • Link current PA behaviour to MF • Develop goal setting skills/set targets to achieve • Self-monitoring skills (PF tests) • Participation in non-threatening practical assessments (enjoyment)	• Outcome expectations • Social support • Self-efficacy • Intentions • Motivation
Week 5 Improving muscular fitness (practical)	• Revise MF & measuring MF • Participate in a practical PE lesson with a gross motor warm-up activity, dynamic stretches, MF circuit and cool-down • HR is monitored throughout the lesson	• Provide opportunity to participate in enjoyable PA in a supportive environment • Maximal participation is provided for and encouraged • Positive feedback is provided throughout the session • Students are to reflect on their	• Outcome expectations • Social support • Self-efficacy • Motivation

Session focus	Session overview	Behaviour change strategies	SCT/CMT construct
	• Discussion about the type of PA and MF (resistance)	performance and re-assess current PA behaviours	
Week 6 Flexibility (theory)	• Define flexibility • Activities that require MF • Benefits of being flexible • Types of stretching • Improving flexibility (lab) • Linking MF & health • Improving MF • Predicting outcomes from changed MF behaviours • Goal setting task • Link flexibility to lifestyle behaviours	• Provide information on flexibility • Link current PA behaviour to flexibility • Develop goal setting skills / set targets to achieve • Self-monitoring skills (PF tests) • Participation in non-threatening practical assessments (enjoyment)	• Outcome expectations • Social support • Self-efficacy • Intentions • Motivation
Week 7 Improving flexibility (practical)	• Revise flexibility and measuring flexibility • Participate in a practical PE lesson with a gross motor warm-up activity, dynamic stretches, fun stretching routines and cool-down • HR is monitored throughout the lesson • Discussion about the type of PA and improved flexibility	• Provide opportunity to participate in enjoyable physical activities in a supportive environment • Maximal participation is provided for and encouraged • Positive feedback is provided • Students are to reflect on their performance and re-assess current PA behaviours • Link to lifelong behaviours	• Outcome expectations • Social support • Self-efficacy • Motivation
Week 8 Improving health-related fitness through games (practical)	• Revise HRF components • Revise improving HRF • Participate in a student-centred practical PE lesson where students adapt fun games to incorporate HRF • HR is monitored throughout the lesson • Discussion about the type of PA and improved HRF • Summary of health benefits with improved HRF • Evaluation of 'Fit-4-Fun'	• Provide opportunity to participate in enjoyable physical activities in a supportive environment • Maximal participation is provided for and encouraged • Positive feedback is provided throughout the session • Students learn skills in adapting PA to improve HRF • Students are to reflect on their performance and re-assess current PA behaviours • Link to lifelong behaviours	• Outcome expectations • Self-efficacy • Social Support • Motivation
Week 1-8 'Fit-4-Fun' Home Activities	• Participation in an 8 week home activity program • 3 weekdays: MF, flexibility, CRF activities • 1 weekday: fitness assessments • Weekends: family activities & CRF assessment • Weeks 1, 5, 8: Goal setting tasks • Problem Solving Task (assessment)	• Students participate in a range of fun activities with their parents/siblings • Family provide social support throughout the program • Students develop skills in self-monitoring and self-motivating • Students develop skills in goal setting & time management • Students develop skills in assessing & planning to improve the physical environment	• Outcome expectations • Self-efficacy • Social Support • Motivation

Abbreviations:

SCT – Social Cognitive Theory	CMT – Competence Motivation Theory
HRF – Health-Related Fitness	HR – Heart rate
CRF – Cardiorespiratory fitness	MF – Muscular fitness
PA – Physical activity	HW- Homework

The Fit-4-Fun Program includes three major components that are based on the HPS Framework [48]:

Curriculum program: An eight-week x 60 min HPE program based on the NSW K-6 syllabus [537] will be delivered during normal HPE lesson time [537]. The program is designed to improve the knowledge, skills and understanding of students in relation to HRF and also focuses on developing skills in assessing and monitoring HRF components. The program overview has been summarized in Table 5.1. The Fit-4-Fun program will be delivered by a member of the research team who is an experienced physical educator.

Family partnership: Children, their parents and family members will be provided with an eight-week home activity program designed to improve HRF levels using a range of engaging and enjoyable fitness activities, small-sided games and fitness challenges (3 x 20 min per week for eight weeks). Children will select from a wide range of activities that are specifically designed to improve muscular fitness, flexibility and cardiorespiratory fitness. There are also goal setting activities and reflection tasks for students to complete with their parents throughout the program, enabling them to set personal fitness goals, monitor their achievement and to reflect on their progress.

School environment: Schools will be provided with activity task cards outlining the rules and organisation of a range of fun and vigorous games (e.g., small-sided invasion games, skipping challenges) and a variety of equipment for use during break-times. The student directed break-time activities will involve participation in enjoyable games, activities and fitness challenges.

Social support for participation in all program activities will be provided by teachers, parents, and students throughout the intervention period. For example, teachers will verbally encourage students to join in the break-time games, there will be posters pinned at the exit points of the classroom reminding students to complete their home activities and to be active at lunch and recess, Fit-4-Fun leaders (students) will be asked to encourage other students to participate in activities and to make the equipment available for use, and parents will be asked to support and encourage their child at home. In addition, notices will be placed in the school newsletter and local media supporting the program and an incentive/award scheme for student participation will be in place. Students who complete home tasks and participate during curriculum sessions will be eligible to receive a gold, silver or bronze award.

The strategies used in the Fit-4-Fun program to target mediators of behaviour change are as follows:

Enjoyment: Many authors have argued that 'fun' or enjoyment is considered one of the most important reasons that children and adolescents become involved and to continue to participate in physical activity – and a lack of fun or enjoyment is likely to lead them to withdraw [462, 509]. Therefore, all of the programs components will involve participation in 'fun' and engaging physical activities, games, challenges or learning activities that children enjoy.

Self-efficacy: Self-efficacy is the central determinant of health behaviour change in SCT as self-efficacy beliefs directly and in-directly influence motivation, affect and behaviour [73, 475]. Data suggests that there is a positive correlation between self-efficacy and the amount of vigorous physical activity in children and adolescent [489-491].The techniques that are used in the Fit-4-Fun program and that have been shown to significantly improve physical activity self-efficacy, and therefore physical activity behaviours, include goal setting/action planning, positive reinforcement for effort or progress towards a set behaviour, the provision of instruction and feedback on performance, self-monitoring, self-regulation, and the provision of information on consequences of behaviour and skills practice [481].

Supportive Environment: The school's social and physical environments are related to the facilitation or constraint of child and adolescent physical activity [460, 483, 521, 522]. Strategies that have been implemented in the Fit-4-Fun program to improve the school and home environment include: increased access to play and sports equipment, provision of quality physical education lessons, and on-going positive reinforcement and social support from parents, teachers and peers [383, 408, 559].

Control (wait-list control group)

The control group will participate in their usual 60 min/week HPE lesson over the eight-week intervention period and will be delivered by their normal classroom teacher. The lesson content will be determined by the set school HPE program. The control group will receive the Fit-4-Fun program resources at the completion of the study period.

Outcome measures

Demographic information (i.e., age, sex, language spoken at home, country of birth) and physical fitness cognitions (i.e., enjoyment, perceived social support, perceived environmental support, physical activity self-efficacy) will be collected via a questionnaire, and physiological data will be collected using the measures detailed below.

A battery of HRF field-based assessments will be conducted one week prior to intervention commencement. Field-based tests will be used as they provide an alternative to laboratory tests, since they are time efficient, cheaper, require fewer resources and can accommodate for multiple participants at once [309]. The testing environment will be identical for both baseline and follow-up measures and all tests, other than the beep test, will be performed in groups of three or four students with a trained research assistant remaining with the group for all assessments. The physiological fitness tests include:

Cardio-respiratory fitness (CRF)

20 m shuttle run test (Beep test). The participant will be required to run back and forth between two lines, 20 m apart, within a set time limit. Running speed will commence at 8.5 km/h and will increase by 0.5 km/h each minute using the 20 m Shuttle Run Test cadence CD. Participants will be instructed to run in a straight line, to place one foot over the 20 m line and to pace themselves according to the audio CD. The test requires maximal effort and participants are required to run until they can no longer keep up with the speed set by the tape. The level and number of shuttles within the level completed will be recorded [538].

Flexibility

Sit and reach test. Using standardized protocols as detailed in the FITNESSGRAM / ACTIVITYGRAM Reference Guide [539] the participant will perform the sit and reach test on the right leg, the left leg and both legs together. Double leg scores, followed by single leg (back saver) measures will be recorded in centimetres. A negative score on the sit and reach test indicates that the participant does not reach the level of the toes and a positive score indicates that the participant reaches beyond the level of the toes.

Muscular fitness (MF)

Standing jump [540, 565]. The participant will be required to stand with both feet parallel and behind a marked starting line. The participant will be asked to swing their arms backwards and then forwards and to jump with both feet simultaneously as far forward as possible. Two attempts at the jump will be permitted with the furthest jump being recorded in metres. The distance measured is the distance between the starting line and the closest landing position (back of the heel).

Seven-stage sit-up test [541]. The participant will lie on their back, with their knees at right angles and feet flat on the floor. The participant then attempts to perform one complete sit-up for each level in the manner prescribed below, starting at level 1. Each level is achieved if a single sit up is performed in the prescribed manner, without the feet coming off the floor. A second attempt is permitted if a level is not reached. The highest level sit-up correctly completed is recorded.

Level and Description:

0 = cannot perform level 1

1 = with arms extended, the athlete curls up so that the wrists reach the knees

2 = with arms extended, the athlete curls up so that the elbows reach the knees

3 = with the arms held together across abdominals, the athlete curls up so that the chest touches the thighs

4 = with the arms held across chest, holding the opposite shoulders, the athlete curls up so that the forearms touch the thighs

5 = with the hands held behind head, the athlete curls up so that the chest touches the thighs

6 = as per level 5, with a 5 lb (2.5 kg) weight held behind head, chest touching the thighs

7 = as per level 5, with a 10 lb (5 kg) weight held behind head, chest touching the thighs.

Basketball throw test [566]: The participant sits on the floor with their buttocks, back, shoulders and head remaining against the wall and their legs straight with feet together. An assistant places a hoop on top of the participant's toes and the participant assumes the chest pass position with elbows touching the wall. The participant will perform a two-handed chest pass through the hoop and the distance from the wall to the ball's first point of contact on the ground is measured in metres (m). Each participant performs two trials.

Push-up test [539]. The participant will start in push-up position with their hands shoulder width apart and directly below their shoulders. Keeping the back and knees straight, the participant will lower the body until there is a 90-degree angle at the elbows, with the upper arms parallel to the floor, and then they will push back up to full extension of the arms. The push-ups will be performed in time to a metronome set at 40 beats per minute (bpm) and the participant will push-up on one beat and down on the next (20 push-ups per minute). The participant will continue until they can do no more in rhythm. The number of complete push-ups performed will be recorded.

Body composition

Height [566]. Height will be measured without shoes to the nearest 0.1 cm using the stretch stature method on a portable stadiometer (model no. PE087, Mentone Educational Centre, Australia). Height will be measured twice, with accepted values within 0.3 cm. A third measure will be taken if measures are not within the accepted range. The mean of two acceptable measures will be reported.

Weight [566]. Weight will be measured to the nearest 0.1 kg in light clothing and without shoes using calibrated digital scales (Model no. UC-321PC, A&D Company Ltd, Tokyo Japan). Weight will be measured twice, with accepted values within 0.1 kg. A third measure will be taken if measures are not within the accepted range. The mean of two acceptable measures will be reported.

Body Mass Index (BMI) [566]. BMI will be calculated using the formulae BMI = mass (kg)/height $(m)^2$. Body mass index z-scores (BMI-Z) (measures of relative weight adjusted for child's age and sex) [567] will also be used to determine relative weight status based on international data [568].

Physical activity (PA)

The participant will be asked to wear a sealed Yamax SW700 pedometer (Yamax Corporation, Kumamoto City, Japan) during their normal daily activities to measure PA for seven days (including three consecutive days and one weekend day) [542]. This is a validated objective measure of physical activity for use with children and adolescents [161]. The participants will be asked to wear the pedometers at all times other than when sleeping or when they might get wet. Classroom teachers will record the step counts and then reset the pedometers of participants at the start of the school day (9 a.m.) on Monday through to Friday during the assessment periods. On the weekend parents will be asked to record the step count readings of their child and to reset the pedometer as close to 9 a.m. as possible. Any problems with recordings or participation in water-based activities are to be noted on the recording sheet and non-ambulatory activities are to be adjusted for on the daily step count via imputation. If imputation is required then a total of 1000 steps for 10 minutes of MVPA and 1500 steps for vigorous activity will be added to the participants step counts for the given time period [543].

Physical fitness testing experience and attitudes towards physical fitness testing: Student questionnaire

The 'Fit-4-Fun' Student Questionnaire will be administered to participants at baseline, immediate post-intervention and six-month follow-up and has been designed to collect information about the attitudes, opinions, behaviours and characteristics of the children involved in the Fit-4-Fun research project. The questionnaire design and purpose is described below.

Demographic Information: Six structured quick response questions will be used to determine the personal characteristics of the children participating in the study (age, DOB, school year, language, country of birth).

Fitness testing experience: Information relating to the participant's experience with fitness testing is sought through the use of five structured closed and semi-closed questions.

Self-efficacy: Information relating to participant's self-efficacy for PA will be measured using eight questions. The scale uses a single factor five-point Likert format and is an adapted version of an eight-item questionnaire previously developed for use with 5th, 8th and 9th grade girls (PASES) [569-571]. The child is asked to select how much they agree with the eight statements by ticking the relevant circle ('Disagree a lot' through to 'Agree a lot'). Each item is scored from 1 to 5, where a score of 1 indicates low self-efficacy; e.g., 'I can be physically active even if it is hot or cold outside'.

Enjoyment: of physical activity will be assessed through six negatively worded questions. The scale uses a five-point Likert format and is an adapted version of the sixteen-item version of the Physical Activity Enjoyment Scale (PACES) [572] and has been recently validated for use with children [573-575]. The child is asked to select how often they experience the relevant feeling about physical activity by ticking the relevant circle ('Never' through to 'Every day').

Each item is scored from 1 to 5, where a score of 1 indicates low levels of enjoyment; e.g., ‘When I am physically active……..…. It’s no fun at all’.

Social Support for PA: Children are required to indicate the level of social support for physical activity they receive from friends, family and teachers. The three scales use a five-point Likert format and have been adapted from two scales used in the student survey of the Amherst Health and Activity Study [576]. Responses are sought for three items pertaining to social support from friends, four items for social support from family and four items relating to social support provided by teachers. The structured scales use a five-point Likert format and have been recently tested for validity and use with children by Dishman et al. (2009) (family and friend scales only) [574]. The teacher social support scale has been devised for the purpose of this study and follows the structure and wording of the other two scales. Children are asked to select how often a specific form of social support is provided to them during a typical week by ticking the relevant circle (‘Never’ through to ‘Every day’). Each item is scored from 1 to 5, where a score of 1 indicates low levels of social support. Scores are summed and then averaged, resulting in a scale mean; e.g., ‘During a typical week at school, how often do your FRIENDS…. do physical activity or play sports with you?’

Perception of the School Physical Environment: Information relating to the physical environment of the school is sought through eight structured questions in part E of the questionnaire. The scale uses a single factor four-point Likert format and is an adapted version of the two-factor, 20-item questionnaire Q-SPACE developed by Robertson-Wilson, Levesque & Holden (2007)[521]. The child is asked to select how much they agree with the eight statements by ticking the relevant circle (‘Strongly Disagree’ through to ‘Strongly Agree’). Each item is scored from 1 to 4, where a score of 1 indicates a low level of support for physical activity in the school’s physical environment (e.g., availability of equipment, play areas, supervision); e.g., ‘There is sports equipment available for students to use during recess and lunch breaks’.

The School Environment Audit: An audit will be completed by two independent research assistants to evaluate the school environment and its relationship to physical activity. The audit will use a purpose designed scale based on The School Environment Audit Tool [577] and the Physical Activity School Scan (PASS) [578]. The assessor will be asked to rate the quality and quantity of specific physical components of the school environment, including sport and play facilities, surrounding bike paths, playground design, aesthetics and sports equipment.

Process evaluation

The feasibility of the program will be examined using a number of strategies. Measures of recruitment (i.e., evaluation of the recruitment process, dissemination of information and obtaining informed consent), retention (i.e., how many students completed the program and participated in all assessments pre and post-intervention), adherence (i.e., the degree to which staff and students followed the Fit-4-Fun program), and satisfaction (i.e., level of satisfaction and engagement in the program by students, staff and parents) will be used. Evaluation questionnaires will also be administered to determine students' and teachers' perceptions of the various program components, attendance, and participation in extra-curricular activities. A six-point Likert scale format will be used with responses ranging from 'Strongly Disagree' through to 'Strongly Agree' (e.g., 'I think all schools should have the Fit-4-Fun Program'). Focus group interviews involving two to three students and lasting 5–10 minutes will also be conducted by trained research assistants to examine the perceptions of students about the Fit-4-Fun program. The groups will be based on friendship groups (both single-sex and mixed-sex groups) and will utilize standardized semi-structured questions. The anonymous verbal responses will be recorded by the research assistant. The following questions will be asked: What did you like about the Fit-4-Fun program? What didn't you like about the Fit-4-Fun program? Did your activity levels change during the breaks at school? How? Were your parents/family interested/engaged in the home activities? How? How have your skills/attitudes/behaviours towards physical fitness changed over the past eight weeks? How? What changes would you make to improve the program in the future? At the end of the session the participants will also be asked if they have anything else to add or would like to discuss anything further.

Statistical Methods

Statistical analyses 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 $p < .05$. The models will be specified to adjust for the clustered nature of the data and multiple imputations will be considered if the dropout rate is substantial. 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.

Focus group responses will be analysed using an inductive analysis where an initial exploration of the verbal responses will be used to identify any patterns or themes [548]. Using a recursive approach, quotes with similar meanings will be grouped together and labelled with a 'theme' [579]. A concept map will then be created to give a visual display of the themes and to aid in providing an accurate description and interpretation of the focus group data.

5.4 Discussion

The Fit-4-Fun study described in this paper is one of the first RCTs in Australia to specifically target the HRF levels of primary school children. The results of this study will provide further evidence to support the feasibility and efficacy of the Fit-4-Fun intervention for improving the HRF and PA levels of children, along with their attitudes towards physical fitness.

This study addresses some of the limitations found in previous interventions by: (1) specifically targeting all of the components of HRF in primary school children; (2) taking a multi-faceted approach to facilitating behaviour change via the HPS Framework; (3) having a theoretically- and curriculum-based program; (4) extending HRF education beyond the classroom and into the home; and (5) by using enjoyable and engaging learning activities to motivate students to adopt healthy behaviours.

The findings of this study will provide valuable information for other research groups looking to improve the HRF levels of children via school-based interventions. Furthermore, it will ascertain whether the Fit-4-Fun program is an effective program for future large-scale implementation.

5.5 Authors' contributions

NE, PJM, and DRL obtained funding for the research. All authors contributed to developing the protocols and reviewing, editing, and approving the final version of the paper. NE is the guarantor and accepts full responsibility for the conduct of the study. All authors have read and approved the final manuscript.

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5.7 Competing interests

The authors declare that they have no competing interests.

Chapter Six

Improving the fitness and physical activity levels of primary school children:

Results of the Fit-4-Fun group randomized controlled trial

This paper reports the findings of the Fit-4-Fun cluster randomized controlled trial implemented in 2011. The results demonstrate significant improvements in health-related fitness, including cardiorespiratory fitness, body composition and flexibility, and improved physical activity levels in the intervention group. The findings presented in this paper provide further evidence to support the effectiveness of the Fit-4-Fun program for improving the physical fitness and physical activity levels of primary school-aged children. Furthermore, process evaluation results indicate that the intervention was feasible for use in the primary school setting.

This chapter addresses two research questions:

- What is the effect of a school-based intervention (Fit-4-Fun Program) on the health-related fitness and physical activity levels of primary school-aged children?

- What is the feasibility of the Fit-4-Fun Program for improving physical activity and health-related fitness as a curriculum-based Health and Physical Education program in the primary school setting (using measures of adherence, retention, recruitment and satisfaction)?

Eather, N., P.J. Morgan, and D.R. Lubans, Improving the fitness and physical activity levels of primary school children: Results of the Fit-4-Fun group randomized controlled trial. *Preventive Medicine*, 2013. 56(1): p. 12-19. (IF=3.2) (See Appendix 15 for published version.)

6.1 Abstract

Objective: To evaluate the impact of a multi-component school-based physical activity intervention (Fit-4-Fun) on health-related fitness and objectively measured physical activity in primary school children.

Methods: Four Hunter primary schools were recruited in April, 2011 and randomized by school into treatment or control conditions. Participants included 213 children (mean age = 10.72 years ± 0.6; 52.2% female) with the treatment group (n = 118) completing the eight-week Fit-4-Fun Program. Participants were assessed at baseline and six-month follow-up, with a 91% retention rate. Cardiorespiratory fitness (CRF) (20 m shuttle run) was the primary outcome, and secondary outcomes included body composition (BMI, BMI-Z), muscular fitness (seven-stage sit-up test, push-up test, basketball throw test, standing jump), flexibility (sit and reach) and physical activity (seven days pedometry).

Results: After six-months, significant treatment effects were found for CRF.

(Adjusted mean difference, 1.14 levels, $p < 0.001$), body composition (BMI mean, -0.96 kg/m^2, $p < 0.001$ and BMI-Z mean -0.47 z-scores, $p < 0.001$), flexibility (sit & reach mean, 1.52 cm, $p = 0.0013$), muscular fitness (sit-ups) (mean 0.62 stages, $p = 0.003$) and physical activity (mean, 3253 steps/day, $p < 0.001$). There were no group by time effects for the other muscular fitness measures.

Conclusions: A primary school-based intervention focusing on fitness education significantly improved health-related fitness and physical activity levels in children.

6.2 Introduction

Physical fitness is an important predictor of physical and psychological health in children and adolescents [9, 138]. Recent studies demonstrate that children who display high levels of health-related fitness (HRF) (e.g., cardiorespiratory fitness, muscular fitness, flexibility and body composition), have a decreased risk of developing cardiovascular disease and other chronic illnesses [562], are less likely to suffer from anxiety and depression [138], and are more likely to perform better academically [27, 580]. Evidence also confirms that a large proportion of children are unfit [14, 581], that children's fitness levels decline with age and fatness levels increase with age [269], and that children do not participate in physical activity of sufficient volume and intensity to accrue the associated health benefits [137, 174, 581]. Considering the low levels of physical activity typically observed among children and adolescents [216, 582, 583] and secular declines in fitness levels [13, 321, 584], there is an urgent need to develop and evaluate interventions that promote high intensity activity but that are also appealing to children and adolescents. Indeed, the latest national physical activity guidelines include physical fitness parameters [303].

The school, via the curriculum, school ethos and community, has been widely acknowledged as an ideal setting in which to provide physical activity opportunities and to educate students about the importance of physical activity and the value of achieving and/or maintaining HRF standards [48, 303]. The Health and Physical Education (HPE) curriculum is considered to be focal point for physical activity promotion in the school setting [49, 585, 586]. However, studies have questioned the quality and quantity of HPE lessons delivered in primary schools [65, 587-589], with teachers reporting a range of barriers to achieving important student outcomes [36, 37, 49]. Evidently, the development of effective HPE programs that teachers can feasibly deliver, are clearly warranted.

Research in the area of physical activity and HRF in children is growing and the importance of designing and implementing quality HRF programs for children has emerged in the literature [49]. A recent review of school-based physical activity and HRF interventions reported significant treatment effects in at least one measure of physical activity (for all 20 interventions), and six of 11 trials reported a significant positive effect on HRF [49]. However, only two of these physical activity interventions were considered high quality due to their rigorous methodological processes, and the fitness focus was often limited to cardiorespiratory fitness (CRF), rather than all HRF components [49]. There is also limited evidence for physical activity and fitness programs that have a theoretical framework and adopt a multi-component approach (including a HPE curriculum component, behaviour modification focus, family involvement, and delivered by a PE expert) – thus restricting their potential impact on fitness and behaviour [380].

The Fit-4-Fun study was designed to overcome the limitations identified in the literature and to evaluate an innovative school-based physical activity program that utilized the three critical components of the Health Promoting School (HPS) framework [48]. The Fit-4-Fun program aimed to build a school environment/ethos that supports physical activity, to create links between the school and the home via parental and family involvement in the program, and to support teaching and learning through the implementation of a quality HPE program. The Fit-

4-Fun program was also based on Bandura's Social Cognitive Theory and Harter's Competence Motivation Theory and aimed to address possible mediators of behaviour change in relation to physical activity in children (e.g., social support, self-efficacy, supportive environment, enjoyment) [47, 536]. The feasibility of the Fit-4-Fun program was established in a small pilot study and the program was refined based on the process evaluation findings [590]. The aim of the current study was to evaluate the Fit-4-Fun program in a cluster randomized controlled trial.

6.3 Methods / Design

Study design and participants

Ethics approval for this study was obtained from the University of Newcastle, NSW, Australia and the Newcastle-Maitland Catholic Schools Office, and is registered with the Australian and New Zealand Clinical Trials Registry (ACTRN12611000976987). School Principals, teachers, parents and study participants provided written informed consent. The methods of the Fit-4-Fun study have been reported in detail elsewhere [591].

Sample size calculation

A power calculation was conducted to determine the sample size necessary to detect changes in the primary outcome CRF (VO_2max). Based on a previous study by Kolle et al. (2009), an increase of 6 mL/kg/min was regarded as clinically important and achievable in children [563]. Using an alpha of 0.05 and power of 80%, a sample size of 128 was needed to detect a 6 mL/kg/min difference between groups. To account for the clustered nature of the data (an intraclass correlation of 0.03 was found for CRF fitness in the KISS school-based intervention) and potential drop-out, 226 participants were recruited from four schools [407].

In summary, Fit-4-Fun was a group RCT with 226 Stage 3 (Grade 5 and 6) students from four primary schools (mean age 10.7 ± 0.6 years; 52.2% female) located in the Hunter Region, NSW, Australia. Schools were randomized into the Fit-4-Fun treatment (n = 118) or wait-list control conditions (n = 108) following baseline assessments. The random allocation sequence was generated by a computer-based random number-producing algorithm and completed by a researcher not involved in the project to ensure an equal chance of allocation to each group. Assessments were conducted in April (baseline), June (immediate post-intervention) and

December (six-month follow-up), 2011, and completed by trained research assistants who were blinded to treatment conditions at baseline assessments.

Treatments

The Fit-4-Fun intervention was informed by the Fit-4-Fun pilot study [591] and a detailed description of the intervention has been reported previously [590].

Intervention: The development of the Fit-4-Fun program was guided by Bandura's Social Cognitive Theory and Harter's Competence Motivation Theory behaviour [47, 536], and included three major components based on the HPS framework [48]. These included: an eight-week HPE curriculum program (60 min/week), an eight-week home activity program (3 x 20 min per week), and an eight-week daily break-time activity program (recess and lunch). The program was delivered by a member of the research team who is a trained physical educator and a detailed outline of the program components are displayed in Table 6.1.

Control (wait- list control group): The control group participated in their usual 60 min/week HPE lesson over the eight-week intervention period delivered by their normal classroom teacher. The control group received the Fit-4-Fun program resources after the six-month assessments.

Demographic information (i.e., age, sex, language spoken at home, country of birth) was collected via a student questionnaire.

Primary outcome:

CRF was measured using the 20 m shuttle run test using standardized testing protocols [48].

Secondary outcomes:

Muscular fitness was measured using the Standing jump [538], seven-stage sit-up [540, 565], basketball throw [541] and push-up tests [317]. Flexibility was measured using the sit and reach test (back saver) [539]. *Body composition* was determined by calculating body mass index (BMI) using the standard equation (weight[kg]/height[m]^2) and body mass index z-scores (BMI-Z) [539] were also used to determine relative weight status [567].

Physical activity: Participants wore sealed Yamax SW700 pedometers (Yamax Corporation, Kumamoto City, Japan) for seven days (including at least three consecutive days and one weekend day) [568] to determine their physical activity levels. Pedometers have been shown to be a valid and reliable objective measure of physical activity [542]. To minimize the amount of lost data, (i) teachers recorded participants results each morning at the same time, (ii) on weekends an information and recording sheet was sent home to parents, and (iii) teachers were asked to remind students to wear their pedometer during all waking hours. Non-wearing periods (e.g., during participation in water sports), were recorded and adjusted for via imputation (1000 steps for 10 minutes of MVPA and 1500 steps for vigorous activity) [161].

Process evaluation

Measures of recruitment, retention, adherence and satisfaction were used to examine the feasibility of the Fit-4-Fun program. Evaluation questionnaires were administered to determine students' and teachers' satisfaction of the various program components and participation in extra-curricular and break-time activities (see Table 6.1) on a six-point Likert scale from strongly disagree to strongly agree (e.g., 'I enjoyed the theory-based learning activities and labs').

Table 6.1: 'Fit-4-Fun' Program components (Australia, 2011)

'Fit-4-Fun' components	Component description
Curriculum component HPE curriculum program • 60 minutes per week • 8 weeks	• Teacher and student work booklets • An 8-week Unit Plan & 8 x weekly Lesson Plans based on the NSW HPE Curriculum • Theory and practical based lessons 1. Theory – Health-related Fitness 2. Theory/Lab – Cardiorespiratory fitness 3. Practical – Improving cardiorespiratory fitness 4. Theory/Lab – Muscular Fitness 5. Practical – Improving muscular Fitness 6. Theory/Lab – Flexibility 7. Practical – Improving flexibility 8. Practical – Applying the components of HRF • Resource materials (i.e., laminated cards for circuit activities, sports equipment, music) • Key Learning Area integration activities and ideas (e.g., maths and science activities) • Student certificates, prizes and reward system.
Family engagement Home activity program • 20 minutes (3 x per week) • 8 weeks	• 8 week 'Home Activity Program' work booklet and information booklet • Engaging weekly home-based fitness activities, challenges and tasks for children and family members • A selection of individual/partner/group activity options (daily programs involve the students selecting activities targeting each of the HRF components)

	• Weekly goal setting and reflection tasks based on the HRF components • Student assessment task linked to the NSW HPE Curriculum requirements • Participation and family engagement to be assessed via student evaluation questionnaire at three-month follow-up and teacher questioning throughout the intervention period.
School environment Daily break time activities (recess and lunch) • 8 weeks	• Student-directed activities and tasks for use during school break times (e.g., small sided games, challenges and strength activities using playground equipment) • Laminated Task Cards and equipment supplied • Participation will be assessed via self-report at three-month follow-up

HPE = Health and Physical Education

NSW = New South Wales

HRF = Health-related fitness

Statistical methods

Differences between participants in the treatment and control groups at baseline were examined using Chi square ($\chi 2$) and independent samples *t*-tests in PASW Statistics 17 (SPSS Inc. Chicago, IL) software. Means and standard deviations were calculated for all variables, with the significance level set at 0.05 for all analyses.

Statistical analyses was conducted using linear mixed models with PROC MIXED in SAS V 9.1 (SAS Institute Inc, Cary, NC) and alpha levels were set at $p < .05$. Mixed models were used to assess all outcomes (primary and secondary) for the impact of treatment group (Treatment and Control), time (treated as categorical with levels baseline, 10-week and six-month) and group-by-time interaction. This approach was preferred to using baseline scores as covariates, as the baseline scores for subjects who dropped out at three months and/or at six months were retained, consistent with an intention-to-treat analysis [592]. To examine potential clustering of effects at the school level, treatment and treatment-by-time were nested in the school condition and included as a fixed effect. School attended did not significantly contribute to any of the models exploring the effects of primary or secondary outcomes and were removed from the final models.

6.4 Results

Overview

Figure 6.1 illustrates the flow of participants through the trial. Four primary schools were recruited and 213 participants were assessed at baseline in April, 2011. The treatment and control groups were similar for all but two outcome measures (sit and reach test & the seven-stage sit up test) at baseline. Table 6.2 displays baseline demographic information and reports baseline primary and secondary outcomes.

Changes in primary and secondary outcomes

All three-month and six-month data is displayed in Table 6.3. The six-month data will be discussed in detail given that school-based interventions often result in immediate changes in physical activity and fitness, but once the intervention ceases the treatment effects are often lost, or not assessed [49-51].

After six-months, significant treatment effects were evident in CRF (adjusted mean difference = 1.14 levels, $p < 0.001$), body composition (BMI, -0.96 kg/m^2, $p < 0.001$ and BMI-Z, 0.47 z-scores, $p < 0.001$), flexibility (sit & reach mean, 1.52 cm, $p = 0.0013$), muscular fitness (seven-stage sit-up, 0.62 stages, $p = 0.003$) and physical activity (3253 steps/day, $p < 0.001$). There were no group by time effects for three measures of muscular fitness (basketball throw, push-ups and standing jump) (Table 6.3).

Process Evaluation

Recruitment & Retention: All data regarding recruitment and retention are displayed in Figure 6.1. There was no significant difference between study groups with regard to retention ($p > 0.05$).

Adherence: All eight curriculum sessions were presented at the treatment schools with an attendance rate of 94%. Based on self-report, 47.1% of participants (n = 48) participated in the break time activity program on at least three occasions per week. No significant relationships were found to exist between participation in break-time activities and baseline physical activity levels or sex. However, a significant difference existed according to age [($\chi2(8) = 20.63$, $p = 0.008$), 10 yrs $\bar{x} = 2.30$ sd = 1.423, 11 years $\bar{x} = 3.30$ sd = 1.64, 12 years $\bar{x} = 2.67$ sd = 1.803], with older students less likely to participate in break-time activities on more than three occasions per week (1 = every day; 2 = 3–4 times per week; 3 = 1–2 times per week; 4 = not frequently; 5 = never).

Table 6.2: Baseline demographic data, health-related fitness and physical activity scores (Australia, April 2011)

Demographic Characteristics	Control (n = 108)		Fit-4-Fun (n = 118)		Total (N = 226)	
	Mean	SD	Mean	SD	Mean	SD
Age (years)	10.73	0.243	10.71	0.80	1.72	0.61
	No.	%	No.	%	No.	%
Participants born in Australia, n (%)	101	93.5%	113	95.8%	214	94.7%
English language spoken at home, n (%)	106	98.1%	117	99.2%	223	98.7%
Sex (male)	50	46.3%	58	49.2%	108	47.8%
	Mean	SD	Mean	SD	Mean	SD
Beep Test (level)	4.94	1.73	5.21	1.81	5.07	1.77
BMI ((kg/m2)	18.25	3.35	19.01	3.16	18.64	3.27
Sit & Reach (metres)	3.38	9.28	0.255	8.65	1.78	9.07
Basketball Throw Test (metres)	4.04	0.54	3.96	0.55	4.00	0.54
Seven-Stage Sit-Up Test (level)	3.45	1.31	4.2	1.21	3.83	1.31
Push-Up Test (number)	10.06	6.76	4.2	1.21	9.39	7.11
Standing Jump (metres)	1.38	0.24	1.42	0.27	1.40	0.23
Physical Activity (mean steps/day)	11636	2925	11826	3747	11738	3824

sd = standard deviation

% = percentage

No.= number

Satisfaction: Mean scores on the evaluation survey categories ranged from 4.29 to 5.33 of a possible 6 (1=*Strongly disagree* to 6=*Strongly agree*) (see Table 6.4) for the 14 items in the evaluation survey, indicating high to very high overall satisfaction rates for the Fit-4-Fun program. However, students reported difficulties with parent and family involvement in the home program with a mean score of 2.84 and 3.33 of a possible 6 for perceived parental and family involvement. No injuries or adverse effects were reported during the activity sessions or assessments.

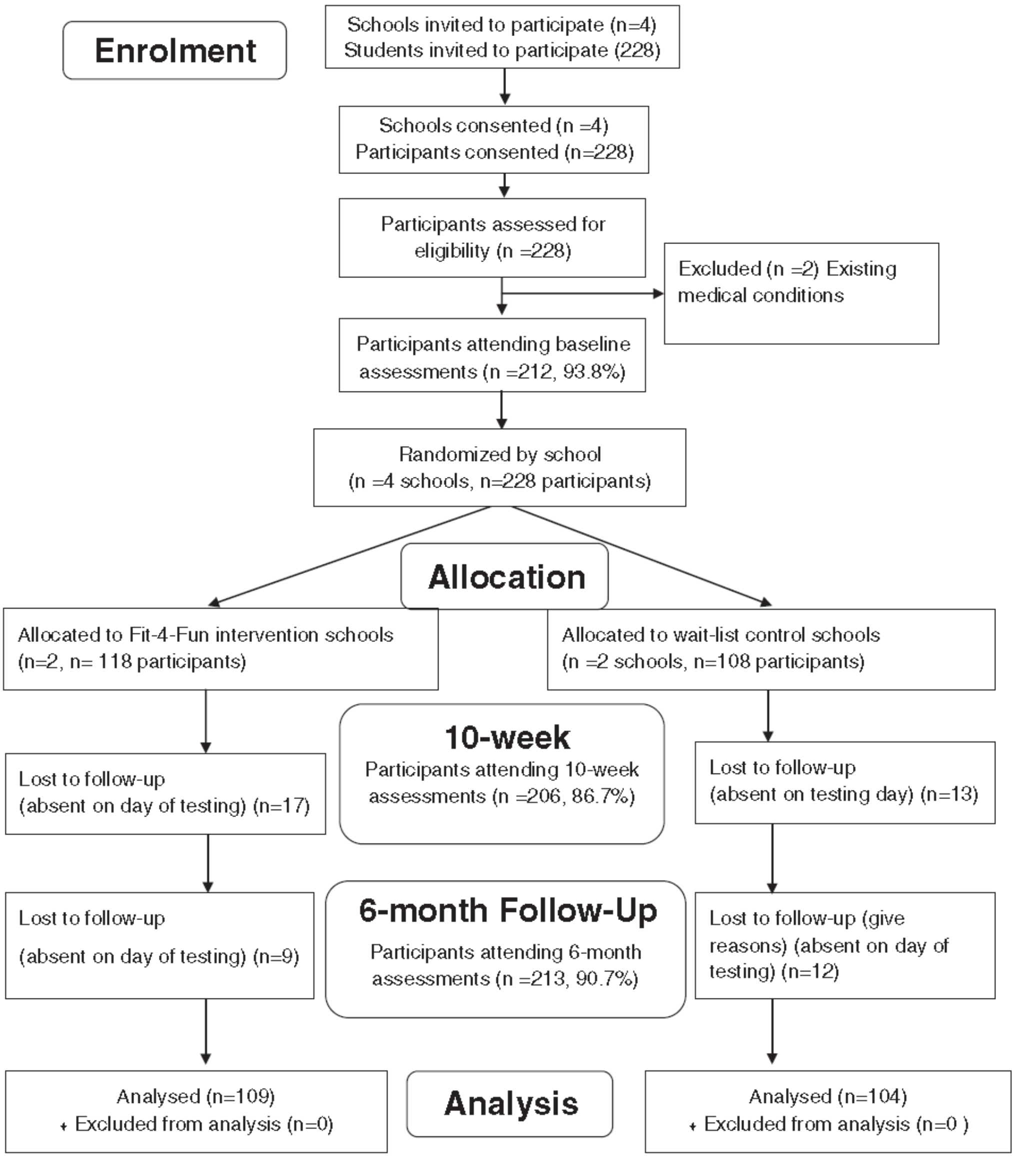

Figure 6.1: Flow of participants through the Fit-4-Fun trial (Australia, 2011)

Table 6.3: Fit-4-Fun Study intervention effects (Australia, 2011)

Outcomes	Time[#]	Treatment Group		Group* Time P value	Treatment effect (95%CI)
		Mean change from baseline (95% CI)[a]			Fit-4-Fun (6m-B) – Control (6m-B)[b]
		Control	**Fit4Fun Intervention**		
Beep (levels)	2 (n=192)	-0.01 (4.52, 5.29)	0.79 (5.67, 6.40)	<0.001	1.14 (0.74, 1.55)
	3 (n=188)	0.09 (4.62, 5.40)	1.24 (6.12, 6.83)		
BMI (kg/m2)	2 (n=196)	-1.68 (-2.00, -1.35)	-0.63 (-0.96, -0.31)	<0.001	-0.96 (-1.42, -0.5)
	3 (n=205)	-1.34 (-1.67,-1.01)	-0.38 (-0.70,-0.06)		
BMI-Z (score)	2 (n=196)	0.68 (0.63, 1.03)	0.17 (0.54, 0.92)	<0.001	-0.47 (-0.70, -0.25)
	3 (n=205)	0.46 (0.40, 0.82)	-0.02 (0.34, 0.74)		
Sit & Reach (repetitions)	2 (n=197)	1.68 (-0.08, 3.44)	1.77 (-0.02, 3.56)	0.0013	1.52 (-0.65, 3.68)
	3 (n=205)	2.44 (0.59, 4.29)	0.86 (-0.90, 2.61)		
Basketball Throw (centimetres)	2 (n=194)	-13.68 (406.33, 429.23)	-6.40 (399.49, 421.53)	0.9459	17.35 (-11.19, 14.7)
	3 (n=205)	-27.59 (418.45, 442.95)	-21.31 (413.79, 437.04)		
Seven Stage Sit Up (level)	2 (n=195)	-0.57 (-0.83, -0.31)	-0.25 (-0.50, 0)	0.0030	0.62 (-0.97, -0.27)
	3 (n=205)	-0.76 (-1.01, -0.50)	-0.14 (-0.38, 0.10)		
Push-Up (repetitions)	2 (n=190)	3.59 (2.29, 4.89)	6.08 (3.98, 8.18)	0.2750	0.03 (-1.66, 1.72)
	3 (n=198)	3.16 (1.93, 4.38)	4.42 (2.45, 6.40)		
Standing Jump (metres)	2 (n=195)	0.17 (0.13, 0.21)	0.17 (0.11, 0.24)	0.1985	0.03 (-0.08, 0.03)
	3 (n=204)	0.15 (0.11, 0.19)	0.18 (0.11, 0.24)		
Physical activity (Steps/day)	2 (n=177)	-2675 (-3539, 1812)	1387 (460, 1996)	<0.001	3253 (1776, 4730)
	3 (n=158)	-797 (-1974, 379)	2615 (1563, 3349)		

BMI = body mass index
CI = confidence interval
[#] Time 2 = 10 week follow-up; # Time 3 = six month follow-up
BMI-Z = body mass index z-score
B = baseline
[a] Time differences were calculated as (10-week minus baseline) and (six-months minus baseline)
[b] Between group differences at six-months (intervention minus control)

Table 6.4: Overall participant satisfaction for the Fit-4-Fun Program (Australia, 2011)

Questions evaluating the Fit-4-Fun Program (n = 102)	Mean	SD
I was excited when I first heard about the F-4-F program	5.19	1.11
The program was easy to understand	5.02	0.87
The program was interesting	5.30	4.19
The program has helped improve my physical fitness levels	5.17	1.14
The program has encouraged me to do more physical activity	5.02	1.24
I think all schools should have the F-4-F program	5.23	1.13
The student workbook was useful	4.29	1.41
I enjoyed the practical fitness activities	5.15	1.01
I enjoyed the theory-based learning activities and labs	4.57	1.34
I enjoyed participating in the F-4-F program	5.33	0.99
The Fit-4-Fun teacher motivated me to participate in the fitness activities	4.95	1.37
The Fit-4-Fun teacher communicated well	4.92	1.66
My involvement in the program has helped improve my knowledge and skills in fitness testing	5.07	1.08
Fit-4-Fun has encouraged me to continue doing fitness activities in the future	4.99	1.27

Questions evaluating family involvement in the Fit-4-Fun Program (n = 102)	Mean	SD
My parents encouraged me to complete the program	3.74	1.79
My parents joined in the home program	2.84	1.71
My brother/sister joined in the home program	3.33	2.27

Likert scores:
1=strongly disagree; 2=disagree; 3= slightly disagree; 4= slightly agree; 5= agree; 6=strongly agree

6.5 Discussion

The primary aim of this study was to evaluate the impact of a novel, multi-component school-based intervention on HRF and objectively measured physical activity in primary school children. Fit-4-Fun was an innovative school-based physical fitness education program promoting and providing opportunities for vigorous intensity activity to improve HRF.

Treatment effects at six-month follow-up were found for CRF, body composition, flexibility, muscular fitness (sit-ups) and physical activity. Our process data also confirms that teachers and students were highly satisfied with the program.

The improvements across multiple HRF domains in this study are particularly encouraging. Significant improvements in the primary outcome, CRF, support previous studies showing that children can improve CRF over time (regardless of weight status) [593, 594], and challenge those researchers who have concluded that physical activity programs are unable to significantly improve CRF in children, due to the relatively high physical activity levels and high inherent aerobic power of children (ceiling effect) [336]. The magnitude of our CRF results exceeded those reported previously [365-367, 377, 380] and may be explained by: (i) the focus on children's exercise intensity and overall physical activity (via fun vigorous chasing activities, invasion games and sport challenges promoted during daily recess and lunch breaks at school, and at home); (ii) the level of support given to children by teachers and parents (in the classroom, in the playground and out of the school setting) [303]; or (iii) to student engagement in the novel program activities (e.g., use of appealing small-sided games, fitness laboratories, fitness circuits and multi-sport challenges). Although limited [49], previous studies support our findings and demonstrate that the physical fitness levels of adolescents can improve relatively quickly using short and frequent periods of enjoyable and engaging fitness activities [49, 442, 550, 595, 596]. Our data also aligns with researchers who have succeeded in increasing levels of physical activity at recess and lunch and who highlight the importance of capturing this 'free time' during the school day to involve children in physical activity [346, 347, 391, 597]. Similarly, research in the area of primary school PE, demonstrates that enhancing the quality of PE programs and instruction, and increasing the amount of higher intensity physical activity within the curricular time, induces physical fitness benefits [49] – especially when the curriculum program is combined with environmental and family components [49, 598] or is delivered by a trained physical educator [416, 431, 436].

Our substantial findings regarding body composition are also greater than those reported previously, with a recent meta-analysis stating that physical activity interventions in primary schools do not significantly improve BMI (weighted mean difference -0.05 kg/m^2) [365, 377, 599]. Our results suggest that changes in fitness may translate into changes in body composition [593, 594], and that school-based HPE programs that promote vigorous physical activity have good potential as an obesity prevention strategy [593, 594].

The literature regarding flexibility training in children is also sparse, with only a few physical activity interventions reporting changes in flexibility [600]. To the authors' knowledge no previous primary school-based physical activity intervention has included strategies designed specifically to improve flexibility in children. One HRF program did not find any treatment effects for flexibility, measured by the sit & reach test [601], but differed from our study in that we included educational and practical activities that focused on flexibility in the curriculum sessions and home program (see Table 6.1), as opposed to a focus on cardiorespiratory fitness, motor skills and nutritional practices.

Our positive findings for physical activity are widely supported in the literature, with the majority of school-based physical activity interventions reporting a significant treatment effect in at least one domain of physical activity (in-school, out-of-school or overall), albeit using varied assessment protocols [49]. A recent successful 10-month primary school-based study called GreatFun2Run by Gorely et al. (2011) reported a significant increase in daily physical activity (Treatment minus Control = 1532 steps per day) [603], which is considerably lower than the improvements found in the Fit-4-Fun study (Treatment minus Control = 3412 steps per day).

The lack of treatment effects for three of the muscular fitness tests (push-up test, basketball throw, standing jump) may be attributed to the self-directed nature of the program and lack of parental participation and/or support. It could be proposed that some students may have opted to perform the 'easier' activities in the home program or to perform the challenging muscular fitness activities less often, especially if they were not supported. This theory aligns with SCT [536] and with Robbins et al. (2004), who propose that levels of self-efficacy and support predict an individual's effort during exercise, their willingness to participate, and the frequency of participation – especially during very intense exercise [536, 602]. The Fit-4-Fun program did target levels of self-efficacy and social support, and pre-intervention 'parent and child' information and practical sessions were held after school. However, parents are notoriously difficult to engage in school-based interventions [603] and parental attendance at these sessions was poor (< 30%), many students were not supported in the home environment regarding completion of home-based tasks, and may not have felt confident to try activities on their own [604].

Emerging data increasingly supports the need for programs that promote and improve muscular fitness in children with evidence showing independent associations between muscular fitness (strength, endurance and power) and insulin sensitivity and clustered metabolic risk [251, 305, 605]. The inclusion of regular 'muscle and bone strengthening' physical activity recommendations in recent national physical activity guidelines, demonstrates the importance of muscular fitness for population health [3, 303]. The development of suitable strategies to increase participation in 'more challenging' muscular fitness activities and to increase parental and family support and participation in these activities is warranted.

The inclusion of fitness education and physical fitness testing in primary schools is a highly debated topic. In the past, fitness testing in schools frequently dominated the fitness education program or was performed in isolation, where learning was not facilitated and the testing environment often invoked negative emotional reactions from students [606, 607]. However, as demonstrated by the Fit-4-Fun Program, the appropriate delivery of fitness training and assessment within a comprehensive HPE curriculum in the primary school can be successful in primary school HPE programs [449, 608]. This study has shown success in using fitness assessment to facilitate the learning of physical fitness concepts and as a tool for developing self-evaluation skills, developing physical activity goals, monitoring progress and motivating children to adopt physically active lifestyle behaviours at school and at home. In addition, the Fit-4-Fun Program has the potential to be a sustainable school-based program as it is based on the HPE curriculum and is not an addition to an existing over-crowded teaching program in many primary schools [37, 65].

Our process data provide interesting insights into the feasibility and success of the program. Recruitment targets were exceeded and retention and attendance rates were very high. Students were also highly satisfied with the Fit-4-Fun Program (see Table 6.4). However, adherence to the home program and regular participation in break-time activities was lower than anticipated – which is comparable to those achieved in the Fit-4-Fun pilot study [590] but higher than those typically observed in secondary school interventions [357, 553, 596]. However, low adherence to the break-time program is not surprising given the evidence showing that the majority of primary school-aged children are spending a large percentage of their recess and lunch in either sedentary or light physical activity, and that participation rates decline with age [213, 391]. Limited playground space and the unwillingness of some students to change their current break-time activities may be possible explanations for our results.

Study strengths and limitations

The multi-component HPE intervention was delivered using the HPS framework, involved a multi-faceted approach to facilitating behaviour change and extended HRF education beyond the classroom. The program was evaluated in a cluster RCT by trained research assistants using validated HRF and physical activity measures [76]. However, there are some limitations that should be noted. Although the use of objectively measured physical activity using pedometry is a strength of this study, pedometers only detect ambulatory activity (and not activities such as resistance training or flexibility training) and therefore true treatment effects might not have been captured. Accelerometers could be used to evaluate future programs as they capture data relating to physical activity intensity, duration and timing [609]. Furthermore, it is impossible to recruit a 'true' control group in the school setting, given that HPE is a compulsory subject and there are 60 mins of mandatory break time available to students during each school day for 'free play.'

Implications

Increasing physical activity and improving HRF in children has emerged as an important health priority. Research has shown that multi-component school-based interventions that involve a collaborative approach to improving physical activity and fitness (involving the school curriculum, the school environment and families) are the most efficacious [49]. The positive results from this study will add to the growing body of evidence supporting the value of school-based interventions that target improvements in physical fitness in children and adolescent and will help inform future intervention design and implementation. Given the program was based on the subject matter of the school curriculum, the program has great potential for future large scale dissemination and/or translation into mandatory primary school HPE programs.

6.6 Conclusion

In summary, the Fit-4-Fun program resulted in significant improvements in HRF, including, CRF fitness, body composition and flexibility, and improved physical activity levels. Our findings provide further evidence to support the effectiveness of a multi-component school-based fitness intervention for improving the physical fitness and physical activity levels of primary school children.

6.7 Author contributions

Study concept and design: Eather, Morgan, Lubans. Acquisition of data: Eather. Analysis and interpretation of data: Eather. Drafting of manuscript: Eather. Critical revision of the manuscript: Morgan and Lubans. Statistical analysis: Eather and Lubans. Obtained funding: Eather, Lubans, Morgan.

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We would also like to thank the schools, teachers and study participants. Eather had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

6.10 Competing interests

The authors declare that they have no competing interests.

Chapter Seven

Social support from teachers mediates physical activity behaviour change in children participating in the Fit-4-Fun intervention

Few studies examine the mediators of behaviour change in successful school-based physical activity interventions. The aim of this study was to explore potential mediators of physical activity in the Fit-4-Fun program based on targeted constructs from Social Cognitive Theory, Competence Motivation Theory and Ecological Theory. Mediation analysis demonstrated that the Fit-4-Fun program successfully targeted social support for physical activity provided by classroom teachers, which contributed to improved physical activity in children. Self-efficacy, enjoyment, social support from parents and peers, and perceived school physical environment were not shown to mediate changes in physical activity in this study. These results add to the limited evidence supporting the pivotal role that classroom teachers play in influencing physical activity in children.

This chapter addresses the research question:

- What are the potential mediators of intervention effects on children's physical activity (e.g., self-efficacy, enjoyment, supportive environment, social support)?

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7.1 Abstract

Background: Few studies have examined the mediators of behaviour change in successful school-based physical activity interventions. The aim of this study was to explore potential mediators of physical activity in the Fit-4-Fun program for primary school children.

Design: Group randomized controlled trial

Methods: Four primary schools were recruited in April, 2011 and randomized by school into intervention or control conditions. Participants included 213 children (mean age = 10.7 years ± 0.6; 52.2% female) with the treatment group (n = 118) completing the eight-week multi-component Fit-4-Fun program. Participants were assessed at baseline, three- and six-months. Physical activity was measured using Yamax SW700 pedometers (mean steps/day) and questionnaires were used to assess constructs from Social Cognitive Theory and Competence Motivation Theory. Hypothesized mediators measured included social support from peers, parents and teachers; physical activity self-efficacy (barrier and task); enjoyment; and perceived school physical environment. Mediation was assessed using Preacher and Hayes' multiple mediation regression SPSS macro. Action theory (A), conceptual theory (B) and the significance of the product of coefficients (AB) are reported.

Results: The intervention had a significant effect on physical activity ($p < 0.001$). The action theory test results revealed significant treatment effects at three-months for perceived school environment ($A = 0.28$, $p < 0.001$); and at six-month follow-up for perceived school environment ($A = 0.058$, $p < 0.001$), teacher social support ($A = 0.54$, $p < 0.05$) and enjoyment ($A = -0.23$, $p < 0.05$). The conceptual theory test revealed a significant relationship between changes in teacher social support and changes in physical activity at six-month follow-up ($B = 828$, $p < 0.05$). Teacher social support was shown to have a significant mediating effect on physical activity (AB = 445, CI = 77 to 1068 steps, proportion = 13%), and perceived school environment approached significance (AB = 434, CI= -415 to 1507 steps, proportion = 13%).

Conclusions: The Fit-4-Fun program successfully targeted social support for physical activity provided by classroom teachers which contributed to improved physical activity in children. These results demonstrate that classroom teachers play a key role in influencing physical activity behaviour outcomes in children.

Key words: Mediators, physical activity, children, school intervention, health-related fitness.

Trial Registration No: ACTRN12611000976987

7.3 Background

Physical activity is an important predictor of physical and psychological health in children and adolescents [9, 138], and physical activity behaviours learned early in life may track through to adolescence and adulthood [610]. Yet research confirms that a large proportion of children do not participate in physical activity of sufficient volume and intensity to accrue the associated health benefits [581, 582]. These trends highlight a need for implementing quality physical activity interventions that specifically facilitate the adoption of health-enhancing physical activity behaviours in children.

Schools have been universally identified as important institutions for the promotion of physical activity in children and adolescent [40], and quality health and physical education (HPE) is central to achieving physical activity goals in the school setting [415, 416]. Consequently, a growing number of small [590, 596, 611] and large-scale [49] school-based physical activity interventions targeting children and adolescents have been implemented. Although these interventions have shown varied levels of success [49-51, 57, 590, 612], there is limited understanding of the causal mechanisms of physical activity behaviour change in school-based interventions [71].

As such, there is growing demand for researchers to explore and report mediators of physical activity change in interventions targeting children and adolescents [71, 462]. Mediation analysis can be used to expand our understanding of physical activity behaviour change in children [463], as testing mediator variables allows researchers to determine which specific components of an intervention were linked to changes in physical activity behaviour [464]. Building evidence around these determinants will guide future intervention development, implementation, evaluation and refinement.

A review of physical activity interventions that reported physical activity outcomes and potential mediators of behavioural change among children [462] identified 19 studies that reported both intervention effects on physical activity and mediators of behaviour change (e.g., knowledge, self-efficacy, enjoyment, attitudes, behavioural capability, intentions, outcome expectancies, social norms, social support and self-concept) [462]. Although several of the reviewed trials reported intervention effects on mediators, none of the studies reported whether changes in these constructs mediated changes in children's physical activity [462]. Similar conclusions were made by Demetriou and Höner (2012) and Lubans et al (2008), in their reviews of school-based physical activity intervention studies in children and adolescents, with both reviews reporting a lack of quality mediation studies – making it hard to conclusively identify mediators of physical activity behaviour change in children and in the school setting in particular [57, 71]. More recently, van Stralen et al. (2011) conducted a systematic review of mediating mechanisms in school-based energy behaviour interventions, and found consistent evidence for self-efficacy as a mediator of treatment effects on physical activity behaviour across 18 reviewed studies [465].

The application of behavioural theory is imperative when designing interventions for children as the theoretical constructs can help researchers determine how the intervention worked and how future interventions can be improved [42, 43]. The Fit-4-Fun program was guided by the socio-ecological model and utilized the three critical components of the Health Promoting School (HPS) framework [48]. Socio-ecological models highlight the important role of the social and physical environment in determining behaviour (and have demonstrated their potential for sustainable behaviour change in school-based interventions [45, 46]), and the Health Promoting School (HPS) Framework is an important theoretical system for promoting health behaviours in the school-setting [48]. Social Cognitive Theory [44] and Competence Motivation Theory [47] are also two behaviour theories that have been applied to the physical activity domain and assert that physical activity can be predicted by physical activity self-efficacy, support (social support and environmental support) and enjoyment [44, 47]. By utilizing existing frameworks for facilitating behaviour change and for creating supportive social and physical environments within the school and home, the Fit-4-Fun program aimed to address possible mediators of behaviour change in relation to physical activity in children (e.g., social support, self-efficacy, supportive environment, enjoyment) [44, 47].

The study protocols of the Fit-4-Fun program and the intervention effects on fitness and behavioural outcomes have been reported elsewhere [590, 612]. The aim of the current study was to explore hypothesized mediators of physical activity behaviour change in the Fit-4-Fun group randomized controlled trial [591].

7.3 Methods

Study design and participants

The Fit-4-Fun program was evaluated using a group RCT with 226 Stage 3 (Grade 5 and 6) students from four primary schools (mean age 10.7 ± 0.6 years; 52.2% female) located in the Hunter Region, NSW, Australia. There were 10 teachers from the four schools (two x treatment and two x control schools), with five classes in each study group (3 x Grade 6 and 3 x Grade 5 in each). Schools were randomized into the Fit-4-Fun treatment (n = 118) or wait-list control conditions (n = 108) following baseline assessments. The random allocation sequence was generated by a computer-based random number-producing algorithm and completed by a researcher not involved in the project to ensure an equal chance of allocation to each group. Assessments were conducted in April (baseline), June (three-month follow up) and December (six-month follow-up), 2011, and completed by trained research assistants who were blinded to treatment conditions at baseline assessments. The study was registered with the Australia and New Zealand Clinical Trials registry (ACTRN12611000976987). Ethics approval for this study was obtained from the University of Newcastle, NSW, Australia and the Newcastle-Maitland Catholic Schools Office, and school Principals, teachers, parents and study participants provided written informed consent. The methods of the Fit-4-Fun study have been reported in detail elsewhere [591], with the trial being adequately powered to detect group changes in the primary outcome cardio-respiratory fitness (CRF)(VO_2max) based on a previous study by Kolle et al. (2009) [563]. In addition, the study was adequately powered to detect a between group difference of 1500 steps and medium-sized mediation effects using a product-of-coefficients test [613].

Treatment conditions

The Fit-4-Fun intervention was informed by the Fit-4-Fun pilot study [590] and a detailed description of the intervention has been reported previously [591]. All of the control schools and treatment schools had the same time allocation for physical education (60 min per week) and for recess and lunch breaks (20 min recess and 40 min lunch).

a) Fit-4-Fun Intervention

Theoretical framework: The Fit-4-Fun Program was grounded in Bandura's Social Cognitive Theory (SCT) and Harter's Competence Motivation Theory (CMT) and aimed to provide children with the knowledge and skills necessary for short- and long-term PA behaviour change [47]. The program aimed to promote the development and maintenance of positive physical activity behaviours and attitudes among participants, by targeting possible mediators of behaviour change (including social support, self-efficacy, supportive environment, enjoyment) [47, 73].

First, a selection of engaging physical activities, games, challenges and learning activities were included in the program to improve 'enjoyment' of physical activity, as the level of enjoyment experienced during physical activity is considered one of the most important reasons that children become involved and to continue to participate in physical activity – and a lack of fun or enjoyment is likely to lead them to withdraw [462, 509]. Second, techniques shown to positively influence physical activity self-efficacy were embedded in the Fit-4-Fun program, as self-efficacy beliefs have been shown to directly and indirectly influence motivation, affect and behaviour [73], and associates with daily vigorous physical activity levels in children and adolescents [489-491]. Third, previously tested strategies to improve physical activity levels by improving the schools' physical environment were employed [383, 408, 524]. In addition, social support for participation in the program activities provided by classroom teachers, parents, and students was a targeted strategy in the Fit-4-Fun program, as social support has been positively associated with physical activity participation in children and adolescents [498, 614-616]. Support for participation in physical activity, in the form of encouragement, was provided verbally by parents, classroom teachers and peers (e.g., teachers prompted children to join in the break-time games as they exited the classroom). Visual aids such as posters pinned on the classroom doors, school newsletter articles, the student work booklets, and a reward system were also utilized to provide support for the program and encourage participants to engage in the program. A full description of the intervention components, the behaviour change techniques and targeted constructs are provided in Table 7.1. A unique feature of the Fit-4-Fun Program was that it encouraged children to participate in vigorous intensity physical activity using games, challenges and learning experiences that were 'fun' or enjoyable and that appealed to children [591].

The Fit-4-Fun Program included three major components based on the HPS Framework [48]:

Curriculum program: An eight-week x 60 min HPE program based on the NSW K-6 syllabus [537] was delivered during normal HPE lesson time [537]. The program was designed to improve understanding and a range of skills in relation to physical activity and fitness (including skills in assessing and monitoring physical activity and HRF levels). The program overview has been summarized in Table 7.1. The Fit-4-Fun program was delivered by a member of the research team who is an experienced physical educator.

Family partnership: Children, their parents and family members were provided with an eight-week home activity program designed to improve the duration, type and intensity of physical activity performed at home using a range of engaging and enjoyable fitness activities, small-sided games and fitness challenges (3 x 20 min per week for eight weeks). Children were given a range of physical activities to choose from, and were encouraged to select activities from each of the physical activity categories (muscular fitness, flexibility and cardio-respiratory fitness). There were also goal setting activities and reflection tasks for students to complete with their parents throughout the program, enabling them to set personal fitness goals, monitor their achievement and to reflect on their progress.

School environment: Students were encouraged to participate in physical activity during recess and lunch each day. To encourage students to be active during this time, schools were provided with activity task cards outlining the rules and organisation of a range of fun and vigorous games (e.g., small-sided invasion games, skipping challenges) and a variety of equipment (e.g. balls, markers, skipping ropes) for use during break-times. This initiative was student-directed and students were asked to support their friends throughout the program by encouraging them to join in the activities and by working together to organize games.

Table 7.1: 'Fit-4-Fun' program content and alignment with theoretical

Wk	**Session focus**	**Session overview**	**Behaviour change strategies**	**SCT / CMT constructs**
1	Health-related fitness (theory)	• Program rationale • Defining PA & PF • HRF & SRF • PA guidelines • Analysing current PA & PF behaviours • Overview of 'Home Activity Program'	• Provide information about PA & PF behaviours/link to health • Develop self-monitoring skills (weekly PA timetable, talk test) • Provide social support and encouragement (to meet PA guidelines) • Participate in age-specific 'fun' physical fitness activities (HW task) • Develop goal setting skills (HW task) • Provide equipment and task cards for use during recess and lunch breaks	• Outcome expectations • Social support (home & school) • Self-efficacy • Intentions • Motivation • Enjoyment • School environment

Wk	Session focus	Session overview	Behaviour change strategies	SCT / CMT constructs
2	Cardiorespiratory fitness (CRF) (theory & practical)	• Provide information on CRF • Role of heart & lungs during PA • Linking heart rate (HR) to PA intensity (lab) • Linking CRF & health	• Provide information about CRF & the role of the heart & lungs during PA • Participate in physical fitness practical laboratory • Develop skills in self-monitoring (using heart rate) • Predicting consequences of actions • Making recommendations relating to PA and CF • Participate in age-specific 'fun' physical fitness activities (HW task) • Provide equipment and task cards for use during recess and lunch breaks	• Outcome expectations • Self-efficacy • Social support • Motivation • Enjoyment • School environment
3	Improving cardiorespiratory fitness (practical)	• Revise CRF & measuring intensity using HR • Participate in a practical PE lesson with a gross motor warm-up activity, dynamic stretches, skill development activities, modified games and cool-down • HR is monitored throughout the lesson • Discussion about the type of PA and heart rate (high intensity/vigorous)	• Provide opportunity to participate in enjoyable physical activities in a supportive environment • Maximal participation is provided for and encouraged • Positive feedback is provided throughout the session • Students are to reflect on their performance and re-assess current PA behaviours • Participate in age-specific 'fun' physical fitness activities (HW task) • Provide equipment and task cards for use during recess and lunch breaks	• Outcome expectations • Social support • Self-efficacy • Motivation • Enjoyment • School environment
4	Muscular Fitness	• Define MF • Muscular strength	• Provide information on MF • Link current PA behaviour to	• Outcome expectations

Wk	Session focus	Session overview	Behaviour change strategies	SCT / CMT constructs
	(MF) (theory & practical)	vs. Muscular endurance • Activities that require MF • Measuring MF (lab) • Linking MF & health • Improving MF	MF • Develop goal setting skills / set targets to achieve • Self-monitoring skills (PF tests) • Participation in non-threatening practical assessments • Participate in age-specific '"fun' physical fitness activities (HW task) • Provide equipment and task cards for use during recess and lunch breaks	• Social support • Self-efficacy • Intentions • Motivation • Enjoyment • School environment
5	Improving muscular fitness (practical)	• Revise MF & measuring MF • Participate in a practical PE lesson with a gross motor warm-up activity, dynamic stretches, MF circuit and cool-down • HR is monitored throughout the lesson • Discussion about the type of PA and MF (e.g., resistance training)	• Provide opportunity to participate in enjoyable physical activities in a supportive environment • Maximal participation is provided for and encouraged • Positive feedback is provided throughout the session • Students are to reflect on their performance and re-assess current PA behaviours • Participate in age-specific 'fun' physical fitness activities (HW task) • Develop goal setting skills (HW task) • Provide equipment and task cards for use during recess and lunch breaks	• Outcome expectations • Social support • Self-efficacy • Motivation • Enjoyment • School environment
6	Flexibility (theory & practical)	• Define flexibility • Activities that require MF	• Provide information on flexibility • Link current PA behaviour to	• Outcome expectations • Social support

Wk	Session focus	Session overview	Behaviour change strategies	SCT / CMT constructs
		• Benefits of being flexible • Types of stretching • Improving flexibility (lab) • Linking MF & health • Improving MF • Predicting outcomes from changed MF behaviours • Goal setting task • Link flexibility to lifestyle behaviours	flexibility • Develop goal setting skills / set targets to achieve • Self-monitoring skills (PF tests) • Participation in non-threatening practical assessments • Participate in age-specific 'fun' physical fitness activities (HW task) • Provide equipment and task cards for use during recess and lunch breaks	• Self-efficacy • Intentions • Motivation • Enjoyment • School environment
7	Improving flexibility (practical)	• Revise flexibility and measuring flexibility • Participate in a practical PE lesson with a gross motor warm-up activity, dynamic stretches, fun stretching routines and cool-down • HR is monitored throughout the lesson • Discussion about the type of PA and improved flexibility	• Provide opportunity to participate in enjoyable physical activities in a supportive environment • Maximal participation is provided for and encouraged • Positive feedback is provided throughout the session • Students are to reflect on their performance and re-assess current PA behaviours • Link to lifelong behaviours • Participate in age-specific 'fun' physical fitness activities (HW task) • Provide equipment and task cards for use during recess and lunch breaks	• Outcome expectations • Social support • Self-efficacy • Motivation • Enjoyment • School environment
8	Improving health-related fitness	• Revise HRF components • Revise improving	• Provide opportunity to participate in enjoyable physical activities in a supportive environment	• Outcome expectations • Self-efficacy

Wk	Session focus	Session overview	Behaviour change strategies	SCT / CMT constructs
	through games (practical)	HRF • Participate in a student-centred practical PE lesson where students adapt fun games to incorporate HRF • HR is monitored throughout the lesson • Discussion about the type of PA and improved HRF • Summary of health benefits with improved HRF • Evaluation of 'Fit-4-Fun'	• Maximal participation is provided for and encouraged • Positive feedback is provided throughout the session • Students learn skills in adapting PA to improve HRF • Students are to reflect on their performance and re-assess current PA behaviours • Link to lifelong behaviours • Participate in age-specific 'fun' physical fitness activities (HW task) • Reflection Task (HW task) • Provide equipment and task cards for use during recess and lunch breaks	• Social Support • Motivation • Enjoyment • School environment
1-8	'Fit-4-Fun' Home Activities	• Participation in an 8 week home activity program • 2 weekdays: MF, flexibility, CRF activities • 1 weekday: fitness assessments • Weekends: family activities & CRF assessment • Weeks 1, 5, 8: Goal setting tasks • Problem Solving Task (assessment)	• Students participate in a range of fun activities with their parents / siblings • Family provide social support throughout the program • Students develop skills in self-monitoring and self-motivating • Students develop skills in goal setting & time management • Students develop skills in assessing & planning to improve the physical environment (assessment task)	• Outcome expectations • Self-efficacy • Social Support • Motivation • Enjoyment

Wk	Session focus	Session overview	Behaviour change strategies	SCT / CMT constructs
1-8	Daily break time (recess and lunch) activities	• Student-directed activities and tasks for use during school break times (e.g., small sided games, challenges and strength activities using playground equipment) • Laminated Task Cards and equipment supplied • Participation will be assessed via self-report at 3-month follow-up	• Provide opportunity to participate in enjoyable physical activities in a supportive environment • Maximal participation is provided for and encouraged by peers • Students learn skills in self-motivation/regulation • Link to lifelong behaviours	• Self-efficacy • Social Support • Enjoyment • School environment

Abbreviations:

SCT – Social Cognitive Theory

CMT – Competence Motivation Theory

HRF – Health-Related Fitness

HR – Heart rate

CRF – Cardiorespiratory fitness

MF – Muscular fitness

PA – Physical activity

PF – Physical fitness

HW – Homework

b) Control (wait-list control group)

The control group participated in their usual 60 min/week HPE lesson over the eight-week intervention period delivered by their normal classroom teacher. The lesson content was determined by the existing school HPE program. The control group received the Fit-4-Fun program resources after the six-month assessment.

Measures

Trained research assistants conducted all assessments, which were completed at the study schools using the same instruments at each time point.

Physical activity: Participants wore a sealed Yamax SW700 pedometer (Yamax Corporation, Kumamoto City, Japan) for seven days (including at least three consecutive days and one weekend day) [568] to determine their physical activity levels. Yamax pedometers have been shown to be a valid and reliable objective measure of physical activity in children [161, 617]. Pedometer placement was standardized by placing it on the belt or waistband, in the midline of the thigh. Participants were instructed to put the pedometer on each morning and to leave it on until they went to bed (except when showering or performing water-based activities). To minimize the amount of lost data (i) teachers recorded participants' results on a recording sheet and then reset the pedometer at the same time each morning; (ii) on weekends an information and recording sheet was sent home to parents to complete each morning; and (iii) teachers were asked to frequently remind students to wear their pedometer during all waking hours. Non-wearing periods (e.g., during participation in water sports), were recorded and adjusted for via imputation (1000 steps for 10 minutes of MVPA and 1500 steps for vigorous activity) [161].

Student Questionnaire

Participants completed a questionnaire at baseline, three-month follow-up and six-month follow-up, which was designed to collect information about the attitudes, opinions, behaviours and characteristics of the children. The questionnaire design and purpose is described below.

I. *Demographic information*: age, sex, language spoken at home and country of birth

II. *Fitness testing experience*: Information relating to participants' experience with fitness testing was sought through the use of five structured closed and semi-closed questions (e.g., 'Have you ever participated in a fitness test?')

III. *Theoretical constructs*: Table 7.2 provides a description of the hypothesized mediator scales (i.e., self-efficacy, enjoyments, social support and physical activity environment), the psychometric properties of each scale, and the previously reported reliability and validity data. The mean score for each participant on each scale was calculated at each of the three assessment time-points.

Statistical Analysis

A range of statistical methods are commonly used in mediation analyses (e.g. Baron and Kenny – causal steps approach, Alwin & Hauser – Product-of-coefficients method, and Judd and Kenny – difference in-coefficients)[618, 619]. These methods generally consist of an Action Theory test, a Conceptual Theory test and a Significance Test of the mediated effect [618]. In summary, the Action theory test examines the impact of the intervention on the hypothesized mediators (e.g., social support, enjoyment, physical activity self-efficacy), the conceptual theory test investigates the relationship between changes in hypothesized mediators and changes in the targeted behaviour (e.g., physical activity), and the significance test combines the action and conceptual theory tests to determine the significance of the mediated effect (see Figure 7.1 below) [618].

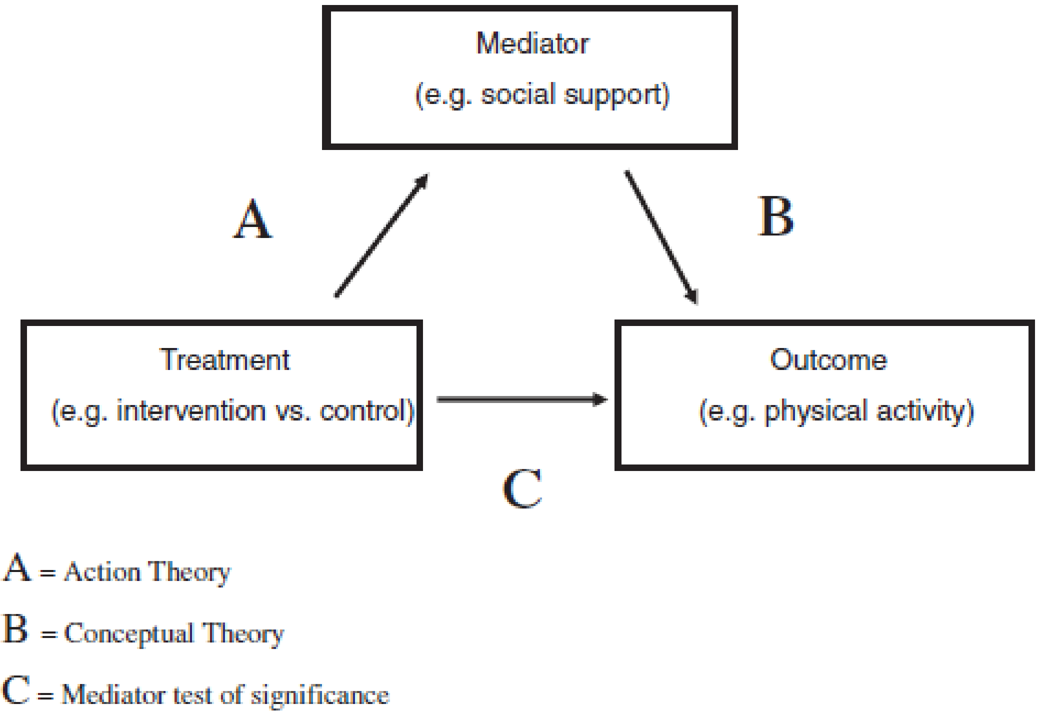

Figure 7.1: Mediation analysis overview

Table 7.2: Description and psychometric properties of hypothesized mediator scales

Hypothesized mediator	Description of scale	Range (no. of items)	Source	α
Barrier self-efficacy	* Single factor 5-point Likert format * Participants were asked to select how much they agree with the eight statements by ticking the relevant circle * E.g. *I can be physically active even if it is hot or cold outside*). * Scale: 1=Disagree a lot to 5= Agree a lot	1-5 8 items	Adapted version of 8-item questionnaire developed for use with 5th, 8th and 9th grade girls (PASES) [569, 570, 620]. The modified scale has been shown to be a valid measure of barrier self-efficacy for this age group (α=.81, ICC=.57) [493], confirmatory factor analysis showed good fit for use with 6^{th} & 8^{th} grade girls (CFI=.98; CFI=0.99)[570]. Factor structure, loadings, factor variance, item means and errors were shown to be invariant across age groups, race / ethnic groups (SE=0.4, 0.024, p<0.001) [574, 621], with good test-retest stability (.84) [493].	1= .75
Enjoyment	* 5-point Likert format The child was asked to select how often they experience the relevant feeling about physical activity by ticking the relevant circle * E.g. *When I am physically active………. It's no fun at all* * Scale: 1=Never to 5= Every day	1-5 6 items (negatively worded)	Adapted version of the a 16-item version of the Physical Activity Enjoyment Scale (PACES) [572] and has been recently validated for use with children (CFI=0.95), with good stability across age groups (SE=0.03;0.24, p<0.001) [572, 575, 622] and good test-retest stability (.73) [493].	1= .72
Social Support **- family** **- peers / friends** **- teacher**	* 5-point Likert format * Participants were asked to select how often a specific form of social support (encouragement or modelling) is provided to them during a typical week by ticking the relevant circle * E.g. Modelling: *During a typical week at school, how often do your FRIENDS do physical activity or play sports with you?* * E.g. Encouragement: *During a typical week at school, how often does your TEACHER.... encourage you to do physical activity during recess or lunch breaks?* * Scale: Never = 1 to Every day = 5	1-5 3 scales Peers (P) (3 items) Family (F) (4 items) Teacher (T) (4 items)	Adapted scale based on two scales used in the student survey of the Amherst Health and Activity Study [576]. Recently tested for validity and use with children in the 6^{th} and 8^{th} grade by Dishman and colleagues (family and friend scales only) [574]. Validity measures indicate that the factor structure, factor loadings and factor variances / co-variances were invariant across race/ethnic groups and across age groups and across time (CFI=0.96; 0.98, SE (friends) =0.41; .027 and SE (family) =0.53; 0.021, p<0.001). The teacher social support scale was devised for the purpose of this study and follows the structure and wording of the family and friends social support for physical activity scales [574].	P1= .68 F1= .65 T1= .77
Perceived school enviornment	* Single factor 4-point Likert format * The participant was asked to select how much they agree with the eight statements by ticking the relevant circle * E.g. *There is sports equipment available for students to use during recess and lunch breaks* * Scale: 1= Strongly Disagree to 4= Strongly Agree (no neutral response)	1-4 9 items	Adapted version of the 2-factor, 20-item questionnaire Q-SPACE developed by Robertson-Wilson, Levesque and Holden [521]. Initial findings support the reliability (α=0.86 and test-retest reliability=0.78) and construct validity of the physical environment sub-scale for use with children and youth [521, 623].	1= .80

Note: Test–retest reliability from cited sources, α – Cronbach's alpha derived from study sample, CFI – comparative fit index, SE – stability co-efficient, ICC – Intra-class correlation co-efficient, Time points: 1=Baseline; 2= three month follow-up; 3=six month follow-up

Preacher and Hayes' (2004) Multiple Mediation Regression [624] macro for IBM SPSS (version 19.0) was used to perform the mediation analyses. This method was determined to be most appropriate given that four level 2 units (schools) were insufficient to provide a reliable estimate of between-school variance using multi-level regression [625, 626]. The Preacher and Hayes macro performs all of the mediation steps simultaneously, but to highlight the output that it generates, the steps are outlined below. Single and multiple (i.e., models included all potential mediators) mediator models were tested and all analyses were adjusted for baseline values. In step 1, the total effect of the intervention on physical activity was estimated by regressing physical activity onto the treatment condition (intervention or control; C coefficient). Step 2 was the Action Theory test, which involves regressing the potential mediators onto the treatment condition (A coefficient). Step 3 was the Conceptual Theory test, which involved regressing physical activity onto the treatment condition (C′ coefficient) and mediators (B coefficient). Step 4, the significance of the product-of-coefficients (AB) was tested by computing the associated asymmetric bias-corrected bootstrap confidence intervals using the INDIRECT add-on for SPSS [624]. Finally, asymmetric confidence intervals were to determine the significance of the product-of-coefficients (AB). For a variable to satisfy the criteria for mediation the 95% confidence intervals (CI) 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)]. The assessment of mediation immediate post-intervention was performed to determine if there were changes in theoretical constructs – and whether they mediated any change in physical activity levels. The assessment of mediation at six-month follow-up was also performed to determine whether possible mediators where present (and whether they had changed) even though the program had finished and the research team no longer had contact with the school.

7.4 Results

Overview: Participants included 213 children (mean age = 10.7 years ± 0.6; 52.2% female) with the treatment group (n = 118) completing the eight-week Fit-4-Fun Program. Participants were assessed at baseline and six-month follow-up, with a 91% retention rate (9% were absent on the day of six-month assessments). Of the 213 participants, 93.5% were born in Australia and 98.1% spoke English at home. At baseline, there were no significant differences between groups for demographic variables (gender, age, country of birth, primary language). A detailed description of the participants' demographics has been reported previously [612].

The intervention effects for health-related fitness and physical activity have been reported previously [612]. In summary, after six-months, significant treatment effects were evident in cardiorespiratory fitness (adjusted mean difference = 1.14 levels, $p < 0.001$), body composition (BMI, -0.96 kg/m^2, $p < 0.001$ and BMI-Z, 0.47 z-scores, $p < 0.001$), flexibility (sit & reach mean, 1.52 cm, $p = 0.0013$), muscular fitness (seven-stage sit-up, 0.6 stages, $p = 0.003$) and physical activity (3253 steps/day, $p < 0.001$). There were no group by time effects for three measures of muscular fitness (basketball throw, push-ups and standing jump).

Three-month results

I. Action theory test: significant improvement in the treatment group for perception of the school physical environment (A = 0.28, $p < 0.001$) was evident at three-months (Table 7.3). There were no significant difference in scores for physical activity self-efficacy, enjoyment, social support from family, friends and teachers ($p > 0.05$).

II. Conceptual theory: there were no significant relationships between changes in the hypothesized mediators and changes in physical activity levels at three-months ($p > 0.05$).

III. Significance test of mediated effect: none of the hypothesized mediators met the criteria for mediation at three-months.

Six-month results

I. Action theory test: significant changes in perceived school environment (A = 0.58, $p < 0.001$), teacher social support (A = 0.54, $p < 0.05$) and enjoyment (A = -0.23, $p < 0.05$) were evident at six-month follow-up (Table 7.3). There were no significant differences in scores for self-efficacy, and social support from family or friends ($p > 0.05$).

II. Conceptual theory: a significant relationship between changes in teacher social support and changes in physical activity levels at six-month follow-up (B = 828, $P < 0.05$) were recorded. There were no significant relationships between changes in the hypothesized mediators ($p > 0.05$) at six-months.

III. Significance test of mediated effect: at six-month follow-up teacher social support was shown to have a significant mediating effect on physical activity (C = 445, CI = 77–1068, proportion = 13%). Perceived school environment approached significance (C = 4037, CI = -415 to 1507, proportion = 13%), while social support from peers and parents, self-efficacy and enjoyment did not meet the conditions for mediation ($p > 0.05$).

Multiple mediator models

I. Action theory test: significant changes in perceived school environment (A = 0.28, $p < 0.001$) and teacher social support (A = 0.47, $p < 0.05$) were evident at six-month follow-up. There were no significant differences in scores for self-efficacy, social support from family or friends ($p > 0.05$) or enjoyment.

II. Conceptual theory: a significant relationship between changes in teacher social support and changes in physical activity levels at six-month follow-up (B = 863, $P < 0.05$) were recorded. There were no significant relationships between changes in the hypothesized mediators ($p > 0.05$) at six-months.

III. Significance test of mediated effect: None of the constructs satisfied the criteria for mediation at six-month follow-up in the multiple mediator models.

Table 7.3: Action theory test, conceptual theory test and significance of the mediated effect on physical activity (step count) – Baseline to 3-months (April – June, 2011) and baseline to 6-months (April – December, 2011) Australia

Hypothesized mediators	Time	Action theory test^		Conceptual theory test		Direct effect		Indirect effect	95% CI	Proportion (%)
		A (SE)	p-value	B (SE)	p-value	C' (SE)	p-value	AB (SE)		AB/(C' + AB)
Self-Efficacy	1	0.04 (0.08)	0.62	1012 (635)	0.11	4368 (621)	<0.001	41 (107)	-107 to 357	1%
	2	0.18 (0.11)	0.10	1081 (587)	0.68	3168 (725)	<0.001	190 (168)	-9 to 717	6%
Enjoyment	1	-0.16 (0.11)	0.14	860 (487)	0.08	4233 (625)	<0.001	-140 (138)	-697 to 19	3%
	2	-0.23 (0.11)	0.05	1002 (527)	0.06	3775 (688)	<0.001	-226 (168)	-732 to 7	6%
Social Support (Friends)	1	0.01 (0.12)	0.91	407 (446)	0.36	4034 (605)	<0.001	-90 (70)	-89 to 247	2%
	2	0.21 (0.14)	0.14	497 (426)	0.25	3423 (703)	<0.001	106 (125)	-34 to 573	3%
Social Support (Family)	1	0.03 (0.11)	0.82	612 (450)	0.18	3911 (605)	<0.001	16 (86)	-112 to 266	<1%
	2	0.06 (0.12)	0.64	516 (515)	0.32	3402 (694)	<0.001	29 (102)	-100 to 411	<1%
Social Support (Teacher)	1	-0.12 (0.15)	0.43	-257 (337)	0.45	3937 (617)	<0.001	32 (78)	-49 to 357	<1%
	2	0.54 (0.17)	<0.001	828 (369)	0.03	3037 (714)	<0.001	445 (242)	77 to 1068	13%
School Environment	1	0.28 (0.07)	<0.001	-605 (733)	0.41	4037 (680)	<0.001	-172 (187)	-574 to 173	4%
	2	0.58 (0.09)	<0.001	742 (723)	0.31	2933 (836)	<0.001	434 (459)	-415 to 1507	13%
Multi-mediation (all)	2					3009 (894)	<0.001	390 (570)	-658 to 1714	11%

1= baseline to 3-month 2= baseline to 6-month

Note. Control and intervention groups were coded '0' and '1' respectively; A = estimate of unstandardized regression coefficient of treatment condition predicting change in hypothesized mediators; B = estimate of unstandardized regression coefficient of change in hypothesized mediators predicting change in physical activity behaviour; AB = product of coefficients estimate; C' = effect of treatment condition on physical activity behaviour controlling for mediator effect; SE = standard error, 95% CI = asymmetric bias-corrected bootstrap 95% confidence interval

7.5 Discussion

The primary objective of this study was to identify if constructs from SCT and CMT mediated changes in physical activity in the Fit-4-Fun school-based intervention. This study demonstrated that the social support provided by classroom teachers mediated the effect of the Fit-4-Fun intervention on physical activity. No other constructs satisfied the criteria for mediation.

Social support is considered an important determinant of behaviour in socio-ecological models and behavioural theories such as SCT [536] and CMT [47]. Importantly, the Fit-4-Fun program included a range of strategies to increase the amount of social support for physical activity provided by the classroom teachers. The findings in this study support the pivotal role teachers have in the promotion of physical activity in schools, on learning in physical education and influencing physical activity levels in children. This is consistent with previous work which has highlighted the relationship between the schools' social environments and children's physical activity behaviours [74, 460, 483, 521, 522, 627]. Teachers in the intervention schools did not allocate additional time for physical activity during the school day, but were encouraged to provide regular support for participation in physical activity (via verbal encouragement during physical education lessons and daily classroom activities, and via school wide promotion strategies such as newsletters, assemblies, and posters displayed around the school). Furthermore, changes in the teachers modelling of positive physical activity behaviour may have influenced perceptions of support by participants, and hence physical activity levels, as the teachers involved would have also developed professionally due to their involvement in the program. Studies have also shown that teachers are able to enhance students' intrinsic motivation for physical activity and their perceived athletic competence when they support physical activity goals and provide positive feedback in a stimulating and supportive classroom environment [66, 628]. Furthermore, teachers have an influential role on learning in the general classroom environment, where the teacher's knowledge, behaviours, and opinions have been shown to be very powerful in the learning equation (accounting for approximately 30% of the variance in learning) [629]. Consequently, it could be anticipated that this influence would also project into learning outcomes in physical education.

In this study, a mediation affect was found at six-month follow-up and not at immediate post-intervention, possibly indicating that the general classroom teacher had increased their confidence and skills to promote high levels of physical activity with their students, and consequently took on the responsibility for providing support for physical activity once the specialist had finished delivering the face-to-face curriculum program. During the Fit-4-Fun program, the classroom teachers were not responsible for delivering any aspect of the Fit-4-Fun program but were able to observe lessons and assist in some minor aspects of set up and student management. Having a highly experienced and qualified physical education teacher come into the school to take the students for an hour each week for PE would have given the teachers the opportunity to observe quality physical education classes and thus provide a unique opportunity for professional development. On the contrary, once the PE specialist had finished the program, the classroom teacher resumed all responsibility for the design, delivery and support for physical activity programs within the school. It is thus plausible that the children recognized and valued the more influential role of their classroom teachers in the period following the program and this support was clearly instrumental in providing the necessary motivation and opportunities for a sustained intervention impact.

Social support from parents did not mediate physical activity behaviours in this study. Our results align with previous school-based physical activity interventions, which have found little evidence for the mediating effect of parents' social support for physical activity on their children's activity levels [467, 468, 630, 631]. The literature consistently refers to the important role that parents and families have on health behaviours, especially physical activity [616, 632], and that researchers have had difficulty in engaging parents in physical activity programs in the past [633]. Consequently, specific measures were taken to engage parents and family members in the Fit-4-Fun program. Parents in the Fit-4-Fun study were given written information about the study via notes, newsletters and information booklets, were invited to attend a parent-child fitness session after school, and were encouraged to participate in the eight-week homework activity program with their child. Kipping (2011) showed that homework tasks are a feasible way of involving parents and that they can serve a range of purposes [634]. In this intervention, homework was designed to encourage children and their parents to participate in a range of enjoyable physical activities together, to learn how to monitor and improve their fitness levels and to encourage families to support each other in achieving physical activity goals. As previously reported [612], parental support for the program was minimal and many children reported lack of involvement by parents. Research has identified the challenges with using homework as a method of involving parents, with many parents lacking time, knowledge, guidance and motivation to support children out of school hours [635]. However, given that parents take on the responsibility of being role models, sources of encouragement, and facilitators of physical activity for children [636, 637], it is important to continue to investigate methods of using engaging homework tasks or other strategies to promote physical activity behaviours among children [638].

Social support for physical activity from friends did not exhibit mediating effects on physical activity behaviours in this study. Research in this area is sparse, with many investigators evaluating the important role of peers as a moderator of social and emotional development [639], rather than physical activity behaviours. One investigation by Salvy et al. (2008) examined the associations between children's physical activity and peers, and found that the presence of peers and friends is associated with higher activity intensity [640]. A more recent study by Lubans, Morgan and Callister (2012) explored the potential mediation effects of peer support on physical activity behaviours in adolescent boys (the Physical Activity Leaders (PALs) program) and reported that peer support did not meet the criteria for mediation in their study [641]. The PALs program implemented a 'Student Leader' system, whereby students took on the role of organising physical activities sessions for their peers and for younger students, and of providing support and encouragement for participation in these physical activities sessions [641]. A possible explanation for the PALs' findings could be linked to participants' 'heightened awareness', whereby students become more aware of the support they were not receiving, affecting follow-up data. The potential to utilize 'Student Leaders' to improve physical activity levels in the younger age group was explored in the Fit-4-Fun study, with students given the opportunity to take on the role of 'Student Leader' during break times. The role entailed encouraging classmates to be active at recess and lunch, collecting the equipment for use during break times, and taking the break-time game cards out into the playground each day (for a period of two weeks). In general, the children in the Fit-4-Fun study did not embrace this system and this aspect of the intervention was poorly implemented. Further investigation into designing appropriate strategies to engage children and adolescents and teachers in promoting activities during break-time and to increase social support from peers should be considered.

Contrary to recent data suggesting that both self-efficacy and enjoyment are positively associated with physical activity in children and adolescents [71, 462, 465, 489-491, 574, 642, 643], neither variable satisfied the criteria for mediation in the current study. Self-efficacy is the most commonly assessed mediator and receives the strongest support for mediating the relationship between school-based interventions and physical activity in children and adolescents [57, 71, 462, 465]. In this study, it was envisaged that targeting self-efficacy would directly and indirectly influence motivation, affect and physical activity, respectively [73, 475].

Although several strategies were used in the Fit-4-Fun program to develop physical activity self-efficacy (e.g., goal setting, positive reinforcement for effort or progress towards a set behaviour, the provision of instruction and feedback on performance, self-monitoring, self-regulation, the provision of information on consequences of behaviour, and skills practice) and enjoyment (e.g., the inclusion of “fun” and engaging physical activities, games, challenges and learning activities), a ceiling effect may have nullified our analyses. The relatively high self-efficacy scores (mean self-efficacy baseline = 4.23/5.00) and enjoyment scores (mean enjoyment baseline 4.41/5.00) at baseline, implies that the children had relatively high levels of confidence in their ability to perform physical activities and enjoyed participating – limiting the scope of the intervention to improve these constructs. Recent data also suggests that enjoyment is positively associated with physical activity in children and adolescent, yet we did not exhibit an intervention effect for enjoyment or satisfy the criteria for mediation in this study. Multiple strategies were implemented in the Fit-4-Fun program to improve enjoyment of physical activity (e.g. the inclusion of ‘fun’ and engaging physical activities, games, challenges and learning activities), but the high baseline enjoyment scores (mean enjoyment baseline 4.41/5.00) indicate that the children already enjoyed participating in physical activity– creating a likely ceiling effect and limiting the scope of the intervention to improve this targeted construct. Alternatively, the limited/negative impact on enjoyment may be explained by the intense nature of the physical activities utilized in the Fit-4-Fun program. Research by Schneider and associates [644, 645], has shown that the proportion of children and adolescents who experience a positive enjoyment affective response to hard exercise is relatively small and although the activities in the Fit-4-Fun program were specifically designed to maximize enjoyment, they still required participants to work vigorously and to perform ‘hard’ muscular fitness activities – potentially perceived as less enjoyable than ‘easier’ or less intense physical activities. Furthermore, the enjoyment scale used in the student questionnaire (adapted version of the 16-item Physical Activity Enjoyment Scale (PACES) [622] may not have been suitable for capturing true intervention effects in this study. The 6 questions in the enjoyment scale did not target specific types of physical activity or differentiate between physical activity settings – making it difficult to establish whether these changes in enjoyment are a result of ‘response shift’ (where a child’s perception of enjoyable physical activity changes as a result of experiencing new and more enjoyable activities). However, given that the mean scores for enjoyment were found to be greater than four at all three assessment time points (indicating that most children answered ‘never’ or ‘once’ to negative feelings during physical activity), this could be viewed as a positive result. The design and validation of specific scales assessing enjoyment of physical activity in specific settings and at different time periods throughout the week are clearly needed.

Furthermore, children are generally optimistic about their abilities, but these start to decline during adolescence. This was demonstrated in another physical activity intervention by Lubans et al. (2010), who also found that physical activity self-efficacy did not mediate changes in physical activity behaviour in adolescents [631]. However, it is worth noting that the distinction between barrier self-efficacy (confidence to overcome a barrier) and task self-efficacy (confidence to perform a task) is often overlooked, with most physical activity interventions assessing barrier self-efficacy only (which children might have difficulty recognising) [475]. In the current study, a general self-efficacy scale was used, where barrier and task self-efficacy were assessed simultaneously. In the PALs study [641], there was a significant impact on task self-efficacy, implying that perhaps more physical activity studies involving children and adolescents (especially children) should explore students' confidence in their skills. In addition, the use of existing self-efficacy scales (whether they focus on barrier self-efficacy, task self-efficacy or both) may not be capturing the true effect of physical activity interventions – especially in children. The design and use of specific scales assessing both self-efficacy constructs (independently) may provide a better insight into the factors mediating physical activity behaviours in children.

The school's physical environment is also an area that has received much attention in promoting physical activity in the school setting [45, 467]. The provision of adequate space, playground equipment, non-fixed sports equipment and non-curricular opportunities during break times in the school day (recess and lunch), has shown to relate to the amount and intensity of physical activity that school children participate in during these times [347, 389, 561, 646]. Our intervention results indicated that participants' ratings of their school physical environments declined from baseline to three-month, and from baseline to six-month follow-up. Possible explanations for these results may relate to the suitability of the school environment scale used in the student questionnaire (and it ability to reflect the intervention components designed to change physical activity behaviour), to the ceiling effect created by the relatively high participant scores at baseline, [647]. In the Fit-4-Fun study, it is possible that participants in the intervention group became increasingly aware of how to increase their physical activity levels during break times and sought opportunities to do so. However, although schools were encouraged to provide access to sports equipment during breaks and additional sports equipment was provided to schools (e.g., balls, skipping ropes), limited changes to the fixed play equipment (both intervention schools had considerable existing climbing equipment, undercover play areas, playground markings and target equipment) and to the size of the playground, would have hampered the potential to improve ratings in these areas.

Study strengths and limitations

This study has noteworthy strengths that include: a novel intervention targeting physical activity and fitness in children, a high quality trial that adhered to the CONSORT statement [76], excellent study adherence and participant retention and the assessment of physical activity using an objective measure. However, there are some study limitations that should be observed. First, due to the process of randomization by school and the small number of clusters (four schools), statistical analysis were not adjusted for the clustered nature of the data. Second, the study was not adequately powered to detect small mediation effects and was underpowered for the multiple mediation models.

Additionally, mediation analysis using Preacher and Hayes' Multiple Mediation Regression [624] uses completers analysis for missing data, however, high retention rates at three-month and six-month follow-up in this study minimized the impact that this procedures has on the results. For future consideration, the study sample was relatively homogenous and future implementations of the Fit-4-Fun study should be extended in size and scope in order to represent a broader population and explore the generalizability of the study findings. Furthermore, data should be collected to assess the specific type and frequency of encouragement provided by teachers during the intervention period. Despite these limitations, the information from this study may be useful in informing future large scale Fit-4-Fun intervention implementation, and in the design of similar research projects targeting physical activity in children. Data in this area is very limited and our results will add to the growing body of research focusing on understanding physical activity behaviours in children and adolescents.

7.6 Conclusion

Mediation analysis is an important component of physical activity research and is a useful tool in identifying the variables responsible for changes in physical activity [648]. Our study has shown that a school-based physical activity program for children (Fit-4-Fun) resulted in increased physical activity levels which were mediated by changes in teacher support for physical activity. These findings concur with research suggesting that the teacher holds the key to learning in schools [629], and suggest that researchers targeting children in the school setting should utilize the influence of the teacher in promoting positive physical activity behaviours both at school and at home. The lack of mediation effect for the other targeted variables (social support from peers and parents, enjoyment, school physical environment, self-efficacy for physical activity) should be addressed and changes in program strategies designed to modify these variables warrants further investigation.

7.7 Financial disclosure

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7.8 Author contributions

Study concept and design: Eather, Morgan, and Lubans. Acquisition of data: Eather. Analysis and interpretation of data: Eather. Drafting of manuscript: Eather. Critical revision of the manuscript: Morgan and Lubans. Statistical analysis: Eather and Lubans. Obtained funding: Eather, Lubans, Morgan.

7.9 Competing interests

The authors declare that they have no competing interests.

Chapter Eight

Discussion

8.1 Introduction

In this chapter, an overview and synthesis of the key findings of the series of published papers will be presented. The detailed results of the Fit-4-Fun pilot study and cluster RCT have been previously presented and discussed in Chapters Four and Six, so a collective overview and interpretation of the implications and recommendations will be provided below. The chapter begins with a summary of the main findings and an overview of how the Fit-4-Fun program developed from conception to pilot study to cluster RCT. Study significance and limitations are then presented, implications for professional practice, pre-service education and teacher training in schools, and recommendations for future research are discussed.

8.2 Purpose of the study

The aim of this study was to investigate the effectiveness of a multi-component school-based program (Fit-4-Fun), designed to improve the physical activity and health-related fitness levels of primary school-aged children. The Fit-4-Fun program was a novel school-based physical fitness education program designed specifically to target areas of both public health and educational concern, as identified in the literature, namely, inadequate physical activity levels [61-64] and declining physical fitness levels of children [12-21], and the need for quality physical education programs and resources in primary schools [41, 65-70]. The Fit-4-Fun program was theoretically grounded, encompassed all of the components of a Health Promoting School [518], extended learning beyond the classroom, and provided professionally designed curriculum resources for classroom teachers. Furthermore, the Fit-4-Fun program included a range of engaging physical activities that encouraged participation in high intensity physical activity, and included a range of exercises designed to improve children's health-related fitness.

8.3 Fit-4-Fun Pilot Study

The Fit-4-Fun pilot study [590] was conducted in 2010 to assess the feasibility and preliminary efficacy of the Fit-4-Fun program for improving physical activity and health-related fitness in children. Conducting this preliminary trial was an important step to determine whether the Fit-4-Fun program produced the intended effect under ideal circumstances (i.e., the entire program was delivered by a member of the research team to a small sample of children) [649]. This was an important stage to determine the potential benefits of the Fit-4-Fun program and establish areas of the program structure, implementation and evaluation that may be in need of refinement or improvement in future trials. The pilot study produced some promising results with significant intervention effects observed in measures of muscular fitness and flexibility. Importantly, the process evaluation results indicated that Fit-4-Fun was a feasible and efficacious school-based physical fitness education program that was highly valued by both participating teachers and children.

Process evaluation results regarding recruitment, retention, curriculum program adherence and satisfaction indicate that the methodological processes and the program content were suitable. However, adherence to the home program and break-time programs varied among the student sample. A number of students reported a lack of involvement and support from parents at home and barriers to the implementation of the break time activity component emerged, which affected the range of high intensity, active games provided at the intervention school during recess and lunch. Difficulties in engaging parents in school-based physical activity interventions is consistent with findings in the literature [486, 553, 554, 603], and may adversely influence the success of an intervention. Similarly, constraining elements present in the school physical environment (e.g., lack of space, play equipment, facilities and safe play areas) also have the potential to hinder the success of a program [74, 460]. These findings are consistent with those presented in a review of correlates of physical activity in children by Sallis et al. (2000), who reported that access to physical activity facilities, equipment and programs, and time spent outdoors were positively and consistently related to children's physical activity [460]. Accordingly, the findings of the pilot study served to guide the development and implementation of the revised Fit-4-Fun in a cluster RCT conducted in 2011.

To improve the Fit-4-Fun program and strengthen its study design and potential impact, a number of refinements were made, including the strengthening of the trial design to a cluster RCT. Refinements included the following:

1) Home Environment

A need to improve parent engagement in the Fit-4-Fun program and support of their child's participation in the program was identified. Social Cognitive Theory [73] and the Health Promoting School Model [518] asserts that the amount of social support and involvement afforded by parents is a key component in initiating and maintaining healthy physical activity behaviours in children, and in developing community links in a health promoting school. In addition, a systematic review conducted by Edwardson and Gorley (2010) highlighted the need for parents to be directly involved in physical activity programs, where they can be active and also be an active role-model for their child(ren) [557]. The Fit-4-Fun home activity program included a range of child-parent fitness activities and challenges, and aimed to encourage parents to participate in the program with their child. Based on the process evaluation results in the pilot study, an after-school information and activity session was added to the program, and conducted for parents and children prior to the commencement of the program. It was anticipated that involving parents in the program at an early stage would ensure that parents were well-informed, felt included in the running of the program and understood the requirements, expectations and benefits. Parents were also asked during the information session and in the home activity booklet to participate in the program with their child and to support their involvement.

2) School Setting

The amount of on-going social support provided by staff and students participating in the Fit-4-Fun program needed to increase to ensure that a supportive learning environment was established throughout the intervention period and beyond – an environment where all students felt confident to perform the required activities in class, during recess and lunch, and at home. Therefore, all students in the program were asked by the program facilitator (Narelle Eather) during the initial session of the Fit-4-Fun program to provide frequent on-going verbal encouragement for participation in the program. More visual aids were utilized, with Fit-4-Fun posters being displayed in the classroom and on the school noticeboards; reminder notes were displayed at the exit of each classroom to remind students to be active at recess and lunch, and at home; articles promoting the Fit-4-Fun program were included in the school newsletter and the local newspaper; and a radio broadcast was aired on the local radio station regarding the potential benefits of the program. Additionally a rotational student-leader system was implemented to support participation in break-time activities. In this initiative, each student was allocated a week during the intervention period, to take responsibility for collecting sports equipment and the game cards from the storeroom for use during recess and lunch. Minimal changes to the curriculum program, break-time games and home fitness program were required. However, based on qualitative feedback from participants, the home activity program was cut back from four days per week to three days per week, to minimize the time burden on busy families during the school term.

3) Outcome measures

Changes to the physiological and psychological assessments were also made in response to the outcomes of the Fit-4-Fun pilot study. First, two measures of health-related fitness were altered in the test battery. Research indicates that the standing jump test has the greatest reliability as a measure of lower limb muscular fitness in children [9, 309, 314, 565], and therefore replaced the wall squat test. Second, the student questionnaire was amended to not only capture different attitudes and opinions of participants, but to also minimize the literacy difficulties faced by students in the pilot study. In the original questionnaire, students completed an adapted version of both Harter's Perceived Physical Competence Subscale for Children [47] and Fox and Corbin's Physical Self Perception Profile [544] using a structured alternate-format. This format proved to be too complicated for some students and was replaced with the single factor five-point Likert format adapted version of the Physical Activity Self-Efficacy Scale [569-571]. Additionally, the Q-SPACE scale [521] was included in the student questionnaire to assess participant perceptions of the school physical environment using a single factor four-point Likert format. It was anticipated that making the above changes to the program and to the assessment battery would result in improved study methods and outcomes.

All other program components remained unchanged for the second trial of the Fit-4-Fun program.

8.4 The Fit-4-Fun Cluster Randomized Controlled Trial

The cluster RCT of the Fit-4-Fun program was conducted in 2011 [591, 612, 650]. This trial again demonstrated the benefits of the program for improving levels of physical fitness and physical activity in children, but also identified a unique school-based mediator of physical activity behaviour change in children.

This second trial had a much larger sample size (n = 213 vs. n = 49) and an extended follow-up period (assessments conducted at baseline, three- and six-months post-intervention). After six-months, significant treatment effects were found for physical activity and multiple components of health-related fitness, including: cardio-respiratory fitness, body composition (BMI and BMI-Z), flexibility (sit and reach) and muscular fitness (sit-ups). There were no significant changes in muscular fitness measured by the standing long jump, push-up or basketball throw tests. The study showed that the Fit-4-Fun program significantly improved health-related fitness and physical activity levels in children, supporting and building on the results from the pilot study. Of particular note, the significant changes in body composition demonstrated the effectiveness of a short-term high intensity school-based physical activity program on adiposity outcomes, which is contrary to the findings of many studies [50, 57, 377]. A recent meta-analysis suggests that physical activity interventions in primary schools do not significantly improve BMI (weighted mean difference -0.05 kg/m^2) [377]. However, in a cross-sectional study of children, Sveinsson, Arngrimsson, and Johannsson (2009) found a strong association between all body composition variables and aerobic fitness in 9 and 15-year olds [599], and muscular fitness has also been associated with adiposity in children and adolescents [253], suggesting that improvements in aerobic fitness and muscular fitness may result in improvements in body composition. The results from the Fit-4-Fun study support this premise, demonstrating that a program targeting fitness has the potential to improve body composition [593, 594], and that school-based health and physical education programs that promote vigorous physical activity have good potential as an obesity prevention strategy [593, 594].

The lack of treatment effect for the three measures of muscular fitness is most likely attributable to the self-directed nature of the Fit-4-Fun home activity program and the lack of parental participation and/or support found. The home program was the main avenue for developing upper and lower body muscular fitness, whereas the break-time program targeted cardiorespiratory fitness, and the curriculum program focused on educational outcomes and self-monitoring of physical fitness. Based on informal feedback collected during throughout the study, it could be anticipated that some students may have opted to perform the 'easier' activities in the home program or to perform the challenging muscular fitness activities less frequently, especially if they were not supported. This is reinforced by Robbins et al. (2004)

who proposed that levels of self-efficacy and social support predict an individual's effort during exercise, their willingness to participate, and the frequency of participation, especially during very intense exercise [486, 536]. Alternatively, the short-term nature of the activity and lack of compliance with the home activity program may have influenced the effectiveness of the program to improve muscular fitness. Strategies to increase parent engagement and to improve children's motivation to perform physically demanding activities are clearly warranted. Additionally, an increased focus on these elements in the school-based components (i.e., break-time program, curriculum program) could be used to ensure that all muscular fitness activities are completed.

A mediation analysis was performed [651] to explore potential mediators of physical activity behaviour change based on the assessed constructs from Social Cognitive Theory [474], Competence Motivation Theory [47] and Ecological Theory [74]. The constructs included: social support from peers, parents and teachers; physical activity self-efficacy (barrier and task); enjoyment; and perceived school physical environment. Social support provided by the classroom teacher was a significant mediator of the intervention effect on physical activity in this study. The perceived school environment approached significance, but all other variables did not meet the criteria for mediation. This analysis confirms that the Fit-4-Fun program successfully targeted social support for physical activity provided by classroom teachers, which contributed to improved physical activity in children, which is a novel finding. Furthermore, the results support the finding that classroom teachers play a key role in influencing physical activity behaviour outcomes in children throughout the school day. However, the lack of significant mediation effects for the other psycho-social constructs warrant further investigation, as program strategies specifically targeting these areas will need to be developed for future program implementation. A possible explanation for these results may relate to the measurement of these constructs, and that the questionnaires need to be developed further for use with children, or alternatively, it may be that such constructs are less important for influencing behaviour in primary school-aged school children. Although the literature in this area is limited, systematic reviews of the mediators of behaviour change in children have found little evidence for the importance of a range of cognitive, behavioural and interpersonal mediators in children [71, 465].

The process evaluation results demonstrated the success of the Fit-4-Fun program. Very high scores were reported for recruitment, retention, adherence (curriculum program) and satisfaction with the program. These results provide further support for the acceptability of the curriculum content and suitability of the program for use in primary schools. Similar results were achieved for break-time activity involvement, and for parental involvement in both trials of the Fit-4-Fun program, but require further investigation. Although only 47% of students reported participating in the Fit-4-Fun break-time activity program (at least three occasions per week), this score may not provide a true indication of the activity levels of children during this time. A possible explanation for low adherence to the break-time activity program is that participants preferred playing pre-existing active games at recess and lunch, rather than using the game ideas provided in the Fit-4-Fun program, and this was encouraged if the games were physically active. Of concern, is the lack of involvement and perceived social support provided by parents for the home-based activity program. Social Cognitive Theory affirms that perceived social support for parents and family members influence physical activity behaviour in children and adolescents [479].

The findings also indicate that social factors, such as support for physical activity from parents and family members [471, 496-501], are crucial for sustaining physical activity behaviours (and vigorous physical activity) in children and adolescents [471, 487, 503, 504]. Therefore, additional strategies to include parents in the Fit-4-Fun program are needed. Increasing the accountability of children and parents in performing the home program by formally assessing this component, increasing the number of communications to parents during the intervention period, and surveying parents to gain a clearer insight into their attitudes, opinions and behaviours influencing their participation, may be viable steps in improving parental engagement in the Fit-4-Fun program.

8.5 Significance and Strengths

The Fit-4-Fun program is an innovative multi-component school-based physical fitness education program that is one of the first Australian school-based programs to demonstrate effectiveness in improving all elements of health-related fitness and the physical activity levels of children [50]. The program addressed many of the limitations found in previous studies by: (1) specifically targeting all of the components of health-related fitness in primary school children; (2) taking a multi-faceted approach to facilitating behaviour change via the Health Promoting Schools Framework; (3) including a theoretically driven, curriculum-based program (and providing professionally designed curriculum resources for primary school teachers); (4) extending health-related fitness education beyond the classroom and into the playground and the home; and (5) by using enjoyable and engaging learning activities to motivate students to adopt healthy behaviours [50]. The Fit-4-Fun program also aimed to promote the development and maintenance of positive physical activity and health-related fitness behaviours and attitudes among children, by identifying and addressing possible mediators of behaviour change (e.g., social support, self-efficacy, supportive environment, enjoyment) [47, 73, 74]. Importantly, the Fit-4-Fun program could fit into existing school structures (curriculum and time), without adding to the already over-crowded teaching program experienced by many primary school teachers [65, 75]. This is achievable given that the curriculum program addresses mandatory syllabus outcomes in health and physical education, the length of the program fits into the 'typical' yearly structure of primary school health and physical education (i.e., an eight-week unit of work), and components of the program are conducted outside curriculum teaching time (i.e., break times and homework).

The Fit-Fun program was evaluated using a rigorous study design and intervention fidelity was high. The Fit-4-Fun study adhered to the Consolidation Standards of Reporting Trials (CONSORT) guidelines [76] during the implementation and evaluation of both randomized controlled trials. Primary and secondary outcomes were also measured by trained research assistants who were blinded to treatment allocation at baseline, all assessments were conducted using validated physiological and psychological assessments, and additional steps were taken to minimize the risk of bias (e.g., use of intention-to-treat imputation for missing data, inclusion of treatment groups who display similar characteristics at baseline, adequately powered to detect changes in primary outcome). Furthermore, process evaluation measures indicated that the program was delivered as intended, with all curriculum sessions delivered according to the program plan, all students were provided with home activity booklets, and sports equipment/resources were made available for students at each recess and lunch break throughout the program. Participant attendance in curriculum sessions was also high, with a 94% attendance rate across the two studies. Furthermore, implementing two trials of the Fit-4-Fun program has also enabled the assessments and program content to be reviewed and amended where necessary, providing a base of strong evidence for large scale implementation.

8.6 Limitations

Whilst the main strengths of the Fit-4-Fun study were its strong research design and program novelty/feasibility in the primary school setting, there are a number of limitations that should be noted. A limitation of this study is the small number of clusters (i.e., schools) that may reduce the generalizability of the results. In addition, due to the small number of clusters, it was not possible to include a random effect for schools in the linear mixed models.

Variation in the quality of instruction provided by the teachers delivering the Fit-4-Fun program may have also influenced the study findings, but was not assessed in this trial. Previous studies have shown that the physical education specialists are superior to classroom teachers in delivering health and physical education programs in primary schools [559], and the difference in teaching performance between treatment groups may influence participant engagement in the program. However, based on current recommendations, it is advisable to use physical educators or extensively trained classroom teachers [652] in school-based physical activity interventions [41, 58, 340, 349, 406, 420, 429-431] and building strong evidence for introducing health and physical education specialists into all primary schools is an important step for improving the quality of health and physical education programs.

The short-term nature of the program and the relatively short-term follow-up period of six-months is an additional study limitation. In order to determine maintenance effects over the long term, it has been recommended that studies include a one to two year follow-up period [383, 653]. It would also be useful to extend the program to include children from Kindergarten through to Grade 6 (and possibly into secondary school), to not only build the knowledge and skills of children sequentially, but to ensure that a continual reinforcement and support of physical activity and physical fitness concepts and behaviours occur throughout their primary school years.

While the objective measurement of physical activity using pedometers was a study strength, such devices are only designed to detect ambulatory activity and may not capture the true treatment effects that might not have been captured. Two key components in the Fit-4-Fun program were resistance training (e.g., calisthenics, isometric holds) and flexibility training (e.g., static, dynamic and PNF stretching), but these physical activities are not accurately measured using pedometers, and therefore participant physical activity scores may be under represented in this study. Accelerometers could be used to evaluate future programs as they capture data relating to physical activity intensity, duration and timing [609]; however, the high cost of accelerometers is often problematic when measuring physical activity in large samples and studies have not confirmed that accelerometers are more sensitive to the types of activities outlined above.

Randomized controlled trials are considered to be the ‘gold standard’ for evaluating interventions [76, 654]. Having a control group allows researchers to compare changes in study outcomes between participants in the group who received the intervention (treatment group) and those who did not (control group) [76]. However, it is impossible to recruit a ‘true’ control group in the school setting, given that health and physical education is a compulsory subject and there are 60 minutes of mandatory break time available to students during each school day for ‘free play.’ It is unrealistic for researchers to expect participants in the control group to do nothing during these periods. Therefore, the classroom teacher was advised to continue delivering their regular school health and physical education program during the intervention period (1 x 60 mins physical education lesson), and the students in the control group were asked to participate in their usual physical activities at recess and lunch. The control group activity levels during their normal HPE lessons and break periods was not monitored and is a limitation of this study. Similarly, children in both groups continued to participate in their normal out-of-school sports and leisure activities during the intervention period. As a result, the extent to which causality can be drawn from the results in the current study is reduced, as changes in physical activity and physical fitness parameters during the intervention period may be influenced by external factors.

8.7 Recommendations / Future Directions

Increasing physical activity and improving health-related fitness in children are important health priorities. Research has shown that multi-component school-based interventions that involve a collaborative approach to improving physical activity and fitness (involving the school curriculum, the school environment and families) are the most efficacious [49]. However, few studies have specifically aimed to improve the health-related fitness levels of children using the school setting, especially in Australia [50, 51]. Consequently, there is a need for schools to embed quality physical activity and physical fitness education programs in the curriculum, and to support school-based programs in the school community via the school ethos and links to the home [518].

Current national guidelines recommend that children should participate in MVPA for at least 60 minutes per day, vigorous intensity physical activity at least three times per week and muscle and bone strengthening physical activities at least three times per week [149-151]. In Australia, schools play an integral part in contributing to the quality and quantity of physical activity opportunities available for children, given that children spend in excess of 30 hours per week at school, and spend over seven hours of this time in recess or lunch break, health and physical education or sport. Although school Principals are encouraged to make a significant contribution towards physical activity goals in Australia [41, 72], accountability for achieving set physical activity requirements and standards in the primary school setting is not governed [41], leading to great variability between schools. Therefore, the implementation of evidence-based physical activity programs that meet the requirements of the curriculum, promote physical activities during break times at school, and extend participation in physical activities into after-school hours (such as the Fit-4-Fun program), provide an excellent strategy for facilitating both enhanced educational and physical activity outcomes.

Social support for physical activity provided by the classroom teacher has proved to be an influential element in the success of the Fit-4-Fun program. Previous studies have also shown that teachers are able to enhance students' intrinsic motivation for physical activity and their perceived athletic competence when they support physical activity goals and provide positive feedback in a stimulating and supportive classroom environment [66, 628]. The amount and type of social support for physical activity participation provided for children has also been shown to directly influence their ability to initiate and maintain physical behaviours [483]. These findings concur with the literature supporting the influential role of the teacher on learning in the general classroom environment, where the teacher's knowledge, behaviours, and opinions have been shown to be very powerful in facilitating learning in children (accounting for approximately 30% of the variance in learning) [629]. In the Fit-4-Fun study, perceived social support provided by teachers has shown to mediate changes in physical activity, and are consistent with previous work which has highlighted the relationship between the schools' social environments and children's physical activity behaviours [74, 460, 483, 521, 522, 627]. However, in this study specific information relating to the type and amount of support provided by parents, peers and teachers was not documented. Consequently, the involvement of the teacher in providing encouragement to be active during the school day should be closely monitored in future implementations of the Fit-4-Fun program. Although evidence supporting the role of the teacher in achieving physical activity and physical fitness goals is building, the results in this study highlight a potential area for future research, and an area to be targeted via professional development for primary school teachers.

The quality and quantity of health and physical education in primary schools is influenced by many factors [65, 75, 416, 655]. Australian primary school generalist teachers have reported a range of barriers (e.g., lack of training, crowded curriculum, lack of confidence and lack of interest) affecting their ability to achieve important student outcomes in a range of health and physical education topics [41, 65]. This may be attributed to inadequate initial teacher education, insufficient on-going professional development, and/or a lack of quality physical education programs and resources available to schools that support curriculum requirements and extend learning beyond the confines of the classroom [65, 75, 416, 655]. Given that quality health and physical education lessons are important for achieving important health and educational outcomes and for developing a range of values, attitudes and essential skills [40], the continued investigation of measures to combat the mentioned barriers is warranted (e.g., developing quality curriculum programs and resources for all topics, continued teacher professional development in health and physical education) [41]. Pre-service training of physical education specialists has also been presented as a method of improving the quality of health and physical education in primary schools [41]. This initiative ranked highest by principals and teachers in a recent Australian survey [41]. Specialist-taught PE lessons have also been shown to improve physical activity levels and achieve higher levels of key outcomes in physical education (including motor performance and fitness) [41, 58, 340, 349, 406, 420, 429-431, 559, 652]. Building strong evidence for the introduction of health and physical education specialists into all Australian primary schools (and many countries internationally) is important, and therefore, the evaluation of teacher behaviour and implementation fidelity in future research is required.

The physical environment of primary schools is also an area that has received much attention in promoting physical activity in children [45, 467, 656]. The provision of adequate space, playground equipment, non-fixed sports' equipment and non-curricular opportunities during break times in the school day (e.g., recess and lunch), has been shown to be related to the amount and intensity of physical activity that school children participate in during these times [347, 389, 561, 646]. The mediation analysis in this study showed that a child's perception of the school's physical environment plays a role in physical activity behaviour change. Consequently, schools can influence physical activity behaviours by making changes to the playground (e.g., the provision of fixed play equipment and accessible grassed areas for play) and by educating children in how to utilize break times to increase their physical activity levels (e.g., accessing sports' equipment, providing game ideas). Furthermore, ongoing support provided by teachers, parents and peers (and embedded in the school ethos) for physical activity during break times is an area of interest for further implementation of the Fit-4-Fun study. In this study, the amount of encouragement given by teachers, parents or even peers for performing physical activity at recess and lunch was not documented, but may provide a valuable insight into the influence of this type of support.

The inclusion of fitness testing was a well-received component of the Fit-4-Fun program. Contrary to some literature [446, 608, 657], a very high percentage of children in the Fit-4-Fun study were interested in knowing how fit they were (95.3%) and enjoyed learning how to assess and monitor their fitness levels. The inclusion of fitness testing in schools has been a highly debated topic, and when performed in isolation or used to compare children, fitness testing has in the past invoked embarrassment and anxiety for the child [449, 558]. Fortunately, fitness testing methods have evolved [317], and when used in combination with a quality fitness education program, fitness testing can be a useful tool for promoting physical activity, facilitating the learning of physical fitness concepts, and helping children link health-related fitness to present and future health status [449, 452]. In this study, the use of fitness assessments also proved to be useful in enabling children to evaluate their fitness levels at home with their family members, to develop short-term physical activity goals, and to monitor progress towards achieving set goals and recommended levels of fitness [451]. Consequently, the inclusion of fitness assessments in primary schools, when used in combination with a quality fitness education program, may facilitate positive physical activity habits. Given, the stigma surrounding the use of fitness testing, this issue has not been explored recently in Australia and is a potential area of interest for physical activity and fitness research [41].

8.8 Future Research Directions for the Fit-4-Fun Program

The comprehensive staged evaluation of the Fit-4-Fun program has provided valuable information to inform future research in this area. Both RCTs provided evidence for the feasibility, efficacy and effectiveness of the program for improving the physical activity levels and physical fitness levels of primary school-aged children. This process has ensured that the three key components of the program (i.e., curriculum, break-time activity and home programs) that were designed based on research and teaching experience, have been put into practice and proven to adequately meet the needs of local students, teachers and schools [658]. This study will also contribute to the limited literature regarding the impact of theoretical constructs on physical activity behaviours in children. This study has shown that the amount of social support for physical activity provided by the classroom teacher is instrumental for improving physical activity levels of children, and should be targeted in future interventions. Furthermore, the perceived school physical environment was shown to be an important facilitator of physical activity in this study, whereas social support for physical activity provided by parents and peers, along with self-efficacy and enjoyment did not mediate changes in physical activity. These results help to inform future intervention design and imply that targeting the school environment may facilitate changes in physical activity and physical fitness in children. Additionally, targeting of social support by parents and peers, self-efficacy and enjoyment may not be a feasible strategy in primary school physical activity interventions. On the contrary, developing new strategies for improving the quality and quantity of social support provided by parents and peers, increasing the physical activity self-efficacy of children and increasing enjoyment of physical activity is warranted.

The next phase for the Fit-4-Fun study is to disseminate the program in primary schools on a larger scale, to explore the generalizability of the results for a broader population in a larger translational trial. Both trials of the Fit-4-Fun program involved relatively small, convenient and homogenous study samples and were conducted in a controlled setting (e.g., Catholic Primary Schools). In addition, the intervention was delivered by a qualified and experienced physical educator. Future studies would involve generalist classroom teachers receiving professional development, program resources and delivering the program. Additionally, conducting and evaluating the program in different locations (e.g., rural, urban), evaluating the results with respect to sex (e.g., girls and boys) and maturation, and conducting and evaluating the program in different school settings using the RE-AIM framework (e.g., state schools, independent schools) presents a range of cultural, economic, and other environmental circumstances that may affect the effectiveness of the Fit-4-Fun program [659]. RE-AIM is a conceptual model that has been used to plan, evaluate, review and report a variety of health promotion interventions, and emphasizes the reach and representativeness of both participants and settings in conducting and evaluating controlled trials [660]. Analysing how these varied influences affect the effectiveness of the program, and adapting the Fit-4-Fun program to fit population and context will be a critical factor in maximising program effectiveness.

Finally, a future long term goal of the Fit-4-Fun program would be to expand the program across all stages of learning (i.e., Kindergarten through to Grade 10) and have the program readily accessible to all classroom teachers. Ideally, the education of children in relation to healthy lifestyles, physical activity and physical fitness should be an on-going process, where curriculum programs build on previously learned skills and understandings. With the impeding introduction of the National Health and Physical Education Curriculum in Australia, the opportunity for introducing a current and evidence-based health and physical education programs is available.

8.9 Conclusions

The aim of this study was to investigate the effectiveness of a school-based physical fitness education program (Fit-4-Fun) for improving the physical activity and health-related fitness levels of primary school-aged children. The Fit-4-Fun program was a theoretically grounded, innovative and engaging school-based fitness education program. It encompassed all of the components of a Health Promoting School, extended learning beyond the classroom and provided professionally designed curriculum resources for primary school teachers. Furthermore, the Fit-4-Fun program entailed a range of specific physical activities which encouraged high intensity participation, and included a range of exercises specifically targeting improvements in health-related fitness, potentially influencing a range of health indices. The Fit-4-Fun program has proven to be both feasible and effective for improving physical activity and physical fitness levels of children, and has shown to be highly regarded by both teachers and students. To support the generalizability of the current findings, future large scale roll outs and evaluation of the Fit-4-Fun program delivered by trained classroom teachers, is required.

8.10 Reference List

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Appendices

Appendix 1: Supervisors' Acknowledgement of Contribution

As co-supervisors of Narelle Eather for the entirety of her PhD study, we, Professor Philip, J. Morgan and Associate Professor David, R. Lubans, acknowledge that Narelle's contribution to the Fit-4-Fun study (as outlined on pages 6 & 7) is accurate and true to the best of our knowledge.

Professor Philip, J. Morgan 15/03/14

Associate Professor David, R. Lubans 15/03/14

Appendix 2: Paper 5

Lubans, D.R., Morgan, P., Callister, R., Plotnikoff, R. C., Eather, N., Riley, N., Smith, C. J. Test-retest reliability of a battery of field-based health-related fitness measures for adolescents. *Journal of Sports Sciences,* 2011. 29(7): p. 685-93 (IF 2.082).

Summary

Given the importance of physical fitness for the current and future health of children and adolescents, it is important that interventions use valid and reliable measures to evaluate health-related fitness. While there are some data to support the validity of field-based measures of physical fitness appropriate reliability data for many of the health-related fitness tests commonly used with children and adolescents is lacking. The main objective of this study was to determine the test-retest reliability of existing field tests of health-related fitness for use with adolescents. The secondary aim of this study was to evaluate the reliability of psychosocial scales for resistance training self-efficacy and outcome expectancy. Results indicate that: the ImpTM SFB7 BIA machine (test of body composition) produced acceptable error estimates but the coefficient of variation was higher among adolescent boys; evidence of systematic bias was found in three of the muscular fitness tests for boys (i.e., leg dynamometer, push-up, and wall squat tests) – even though the intra-class correlation and coefficient of variation values for muscular fitness tests were similar for boys and girls and; both psychosocial scales for resistance training self-efficacy and outcome expectancy demonstrated appropriate variability, indicating suitability for evaluating the effects of resistance training program on cognitions in adolescents and in cross-sectional studies.

Appendix 3: Paper 6

Smith, J. J., Eather, N., Morgan, P. J., Plotnikoff, R. C., Faigenbaum, A. D. and Lubans, D. R. (*In Press*). The health benefits of muscular fitness for children and adolescents: A systematic review and meta-analysis. *Sports Medicine*.

Summary

The association between muscular fitness (MF) and health status has recently received increased attention. The aim of this systematic review and meta-analyses was to evaluate the potential physiological and psychological benefits associated with MF among children and adolescents. The 110 eligible studies, encompassing six health outcomes (i.e., adiposity, bone health, cardiovascular disease [CVD] and metabolic risk factors, musculoskeletal pain, psychological health and cognitive ability), reported strong evidence for an inverse association between MF and total and central adiposity, and CVD and metabolic risk factors, and a strong evidence for a positive association between MF and bone health and self-esteem. The evidence for an association between MF and musculoskeletal pain and cognitive ability was inconsistent. The findings of this review highlight the importance of developing MF during adolescence for a number of health-related benefits.