



**Evaluation of a School-Based Intervention Designed to Improve Health-Related  
Fitness in Adolescent Boys from Schools in Low-Income Communities: The ‘Active  
Teen Leaders Avoiding Screen-time’ (ATLAS) Cluster Randomised Controlled Trial**

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B Teaching / B Health and Physical Education (Hons)

A thesis submitted in fulfilment of the requirements for the award of the degree of:

**Doctor of Philosophy**

**University of Newcastle**

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## **Statement of Originality**

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## **Conflict of Interest**

The ATLAS cluster randomised controlled trial was funded by an Australian Research Council Discovery Grant (DP120100611). This sponsor had no involvement in the research process, including the drafting of this thesis or the manuscripts contained herein. This trial has been registered with the Australian and New Zealand Clinical Trials Registry (ACTRN 12612000978864). Jordan Smith was supported by a University of Newcastle postgraduate scholarship.



## Publications and Presentations Arising from this Thesis

This thesis is comprised of six research papers, all of which have been published in peer-reviewed journals. As seen below, I was the lead author on four of the included papers and appear as a co-author on the remaining two papers.

### Manuscripts published in peer-reviewed journals

1. **Smith JJ**, Eather N, Morgan PJ, Plotnikoff RC, Faigenbaum AD, Lubans DR. The health benefits of muscular fitness for children and adolescents: A systematic review and meta-analysis. *Sports Medicine*. 2014; 44(9), 1209-1223.
2. Lubans DR, **Smith JJ**, Harries SK, Barnett L, Faigenbaum AD. Development, test-retest reliability and construct validity of the Resistance Training Skills Battery. *Journal of Strength and Conditioning Research*. 2014; 28(5): 1373-1380.
3. **Smith JJ**, Morgan PJ, Plotnikoff RC, Dally KA, Salmon J, Okely AD, Finn TL, Babic MJ, Skinner G, Lubans DR. Rationale and study protocol for the 'Active Teen Leaders Avoiding Screen-time' (ATLAS) group randomized controlled trial: An obesity prevention intervention for adolescent boys from schools in low-income communities. *Contemporary Clinical Trials*. 2014; 37(1): 106-119.
4. **Smith JJ**, Morgan PJ, Plotnikoff RC, Dally KA, Salmon J, Okely AD, Finn TL, Lubans DR. Smart-phone obesity prevention trial for adolescent boys in low-income communities. *Pediatrics*. 2014; 134(3): e723-e731.
5. Lubans DR, **Smith J**, Skinner G, Morgan PJ. Development and implementation of a smartphone application to promote physical activity and reduce screen-time in adolescent boys. *Frontiers in Public Health*. 2014; 2(42): 1-11.
6. **Smith JJ**, Morgan PJ, Plotnikoff RC, Stodden D, Lubans DR. Mediating effects of resistance training skill competency on health-related fitness and physical activity: The ATLAS cluster randomised controlled trial. *Journal of Sports Sciences*. 2015. (In press).

### **Conference abstracts: Published in conference proceedings or peer-reviewed journals**

The following conference abstracts encompass two national and two international conferences. As shown below, I personally presented at three of the four conferences. Each of these presentations aligns with the research included within this thesis.

1. **Smith JJ**, Morgan PJ, Plotnikoff RC, Dally KA, Salmon J, Okely AD, Finn TL, Lubans DR. Improving the health-related fitness and movement skills of adolescent boys from low-income communities: The ATLAS cluster RCT. *Oral presentation at the National Physical Activity Conference*. Canberra, Australia; October 15-18, 2014.
2. Lubans DR, **Smith JJ**, Morgan PJ, Plotnikoff RC, Dally K, Salmon J, Okely AD, Skinner G. Description and feasibility of a smartphone application to promote physical activity and reduce sedentary behaviour in adolescent boys. *Oral presentation at the annual meeting of the International Society for Behavioral Nutrition and Physical Activity*; San Diego, USA, May 21-24, 2014.
3. **Smith JJ**, Morgan PJ, Plotnikoff RC, Dally KA, Salmon J, Okely AD, Finn TL, Babic MJ, Skinner G, Lubans DR. Increasing physical activity and improving muscular fitness through school sport: Rationale, methods and baseline findings from the ATLAS program for adolescent boys. *Oral presentation at the International Association for Physical Education in Higher Education (AIESEP) world congress*. Auckland, New Zealand; February 10-13, 2014.
4. Babic M, **Smith JJ**, Harries S, Barnett L, Faigenbaum AD, Lubans DR. Development of a resistance training skills test for school-based research and practice. *Poster presentation at the International Association for Physical Education in Higher Education (AIESEP) world congress*. Auckland, New Zealand; February 10-13, 2014.
5. **Smith JJ**, Morgan PJ, Plotnikoff RC, Dally KA, Salmon J, Okely AD, Finn TL, Babic MJ, Lubans DR. Group randomized controlled trial of the Active Teen Leaders Avoiding Screen-time (ATLAS) obesity prevention intervention for adolescent boys living in low-income communities. *Oral presentation at the Australasian Society for Behavioural Health and Medicine 10<sup>th</sup> annual scientific conference*. Newcastle, Australia; February 6-8, 2013.

## **Additional Publications and Presentations Arising from my PhD Candidature**

Prior to commencing my PhD, I worked on the Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES) group randomised controlled trial; a fundamental movement skills intervention for primary schools in low-income communities. Due to my intellectual and practical contributions, I was invited to contribute as a co-author on a publication relating to this research project. Throughout my candidature I also contributed to a number of additional publications. The following publications are consistent with my research focus. However, they sit aside from the research included within this thesis and were therefore not included. Details of the additional publications and conference presentations to which I contributed are listed below.

### **Additional publications**

1. Barnett L, Reynolds J, Faigenbaum AD, **Smith JJ**, Harries S, Lubans DR. Rater agreement of a test battery designed to assess adolescents' resistance training skill competency. *Journal of Science and Medicine in Sport*. 2015; 18(1): 72-76.
2. Thorne HT, **Smith JJ**, Morgan PJ, Babic MJ, Lubans DR. Video game genre preference, physical activity and screen-time in adolescent boys from schools in low-income communities. *Journal of Adolescence*. 2014; 37(8): 1345-1352.
3. Owen KO, **Smith J**, Lubans DR, Ng JY, Lonsdale C. Self-determined motivation and physical activity in children and adolescents: A systematic review and meta-analysis. *Preventive Medicine*. 2014; 67: 270-279.
4. Lubans DR, Lonsdale C, Plotnikoff RC, **Smith J**, Dally K, Morgan PJ. Development and evaluation of the Motivation to Limit Screen-time Questionnaire (MLSQ) for adolescents. *Preventive Medicine*. 2013; 57(5): 561-566.
5. Lubans DR, Morgan PJ, Weaver K, Callister R, Dewar DL, Costigan SA, Finn TL **Smith J**, Upton L, Plotnikoff RC. Rationale and study protocol for the Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES) group randomized controlled trial: A physical activity and fundamental movement skills intervention for primary schools in low-income communities. *BMC Public Health*. 2012; 12(1): 427.

### **Additional conference presentations**

1. Lonsdale C, Owen K, **Smith J**, Lubans DR. Motivation and physical activity in children and adolescents: A systematic review and meta-analysis of evidence from studies framed by self-determination theory. *Poster presentation at the Asics Conference of Science and Medicine in Sport*. Phuket, Thailand; October 22-25, 2013.
2. Lubans DR, Lonsdale C, Morgan PJ, **Smith J**, Dally K, Plotnikoff RC. Instrument development and initial validity for a scale to measure adolescents' motivation to limit their screen time. *Oral presentation at the Australasian Society for Behavioural Health and Medicine 10<sup>th</sup> annual scientific conference*. Newcastle, Australia; February 6-8, 2013.
3. **Smith JJ**, Morgan PJ, Saunders K, Lubans DR. Improving physical self-perception in adolescent boys from disadvantaged communities: Psychological outcomes from the PALs intervention. *Oral presentation at the 4<sup>th</sup> International Congress on Physical Activity and Public Health, National Physical Activity Conference*, Sydney, Australia; October 31-November 3, 2012.
4. Weaver K, Lubans D, Morgan P, Callister R, Dewar D, Finn T, **Smith J**, Plotnikoff, R. Rationale and intervention description of the Supporting Children's Outcomes using Rewards, Exercise and Skills physical activity intervention. *Poster presentation at the 4<sup>th</sup> International Congress on Physical Activity and Public Health, National Physical Activity Conference*, Sydney, Australia; October 31-November 3, 2012.

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## **List of Abbreviations**

ASAQ	Adolescent Sedentary Activity Questionnaire
ATLAS	Active Teen Leaders Avoiding Screen-time
BMI	Body Mass Index
CI	Confidence Intervals
cm	Centimetres
CONSORT	Consolidated Standards of Reporting Trials
CRF	Cardiorespiratory Fitness
CVD	Cardiovascular Disease
DEC	Department of Education and Communities
ICC	Intra-class Correlation Coefficient
kg	Kilogram
m	Metre
MF	Muscular Fitness
MVPA	Moderate-to-Vigorous Physical Activity
<i>N</i>	Number
NSW	New South Wales
<i>p</i>	Probability (statistical significance level)
PE	Physical Education
RCT	Randomised Controlled Trial
RT	Resistance Training
RTSB	Resistance Training Skills Battery

RTSQ	Resistance Training Skill Quotient
SCT	Social Cognitive Theory
SD	Standard Deviation
SDT	Self-Determination Theory
SEIFA	Socio-Economic Indexes for Areas
SES	Socioeconomic Status
SPANS	Schools Physical Activity and Nutrition Survey
STROBE	Strengthening Reporting of Observational Studies in Epidemiology
SSB	Sugar-Sweetened Beverages
WC	Waist Circumference
WHO	World Health Organisation

## Operational Definitions

Term	Definition
Adolescent	In this thesis, the term adolescent (or adolescence) refers to a young person during the period from the onset of puberty through to the age of legal adulthood. Although puberty may begin earlier, this term will typically be used to describe a young person in secondary school (aged 11 to 18 years).
Body composition	Body composition refers to the relative contribution of different body tissues to total body mass, for example the percentage of body mass comprised of adipose or ‘fat’ tissue. Within this thesis, the terms ‘overweight’ and ‘obese’ - derived from body mass index (i.e., $\text{Weight [kg]} / \text{Height [m]}^2$ ) - will be used to indicate a sub-optimal body composition (i.e., a high body fat percentage) (1).
Cardiorespiratory fitness	Cardiorespiratory fitness, also known as cardiovascular endurance, aerobic fitness and maximal aerobic power, refers to the capacity of the cardiovascular and respiratory systems to sustain prolonged bouts of physical activity (2, 3).
Child	In this thesis, the term child refers to a young person aged 5-11 years and will typically be used to describe a young person in primary school.
Health-related fitness	Health-related fitness refers to the components of physical fitness with recognised links to health. The health-related fitness components are body composition, cardiorespiratory endurance, muscular strength, muscular endurance, and flexibility (2).
Muscular fitness	Muscular fitness refers to the capacity of the musculoskeletal system to generate force maximally (i.e., muscular strength), and quickly (i.e., muscular power), or to perform repeated contractions under sub-maximal load (i.e., local muscular endurance) (2, 4).
Physical activity	Physical activity refers to any bodily movement produced by skeletal muscles which results in an increase in energy expenditure beyond that of resting levels (2).
Resistance training	Resistance training (RT) refers to a specialised method of conditioning, using a variety of resistive loads, aimed at achieving improvements in muscular fitness, health, and sports performance (5).
School sport	In this thesis, school sport refers to the period of the school week allocated to compulsory physical activity. In Australian public schools, time for organised sport is provided on a mandatory basis to junior school students. School sport may occur in a variety of formats (6), but also occurs in addition to regular physical education (PE) lessons.



Screen-time	Screen-time refers to the use of small screen devices, such as television, DVDs, personal computers and laptops, video gaming consoles and hand-held gaming devices, smartphones, and tablets for the purposes of entertainment. This term does not include screen use for the purposes of education.
Sugar-sweetened beverages	The term sugar-sweetened beverages (SSBs) refers to carbonated soft drinks (i.e., soda), cordials, refined fruit juices, flavoured milk, sports drinks and caffeinated energy drinks.

## Thesis Abstract

### Background

Growing concerns over obesity, physical inactivity, and worsening levels of physical fitness among youth have led to a proliferation of school-based intervention studies in recent years. School-based programs aimed at increasing physical activity and fitness, and preventing obesity have demonstrated promise, but results have been inconsistent and short-term. While there is evidence to suggest that previous programs have been less effective for adolescents, there are also relatively few interventions that have been evaluated among this group. Furthermore, many previous interventions have been limited by poor methodological quality. Based on the limited success of previous programs, it has been suggested that future interventions should be directed at specific sub-groups of the population (e.g., males or females). Indeed, there are clear sex differences in regards to key health behaviours (e.g., physical activity, recreational screen-time, and sugar-sweetened beverage [SSB] consumption), suggesting that intervention approaches should be differentiated for boys and girls. It has also been recommended that interventions be evaluated among those most at risk of future ill-health. Youth living in low-income communities are disproportionately affected by poor health outcomes. Consequently, there is a strong rationale for targeted intervention approaches among this population. Finally, considering the recognised links between physical fitness and health outcomes, attempts to engage youth through innovative and theoretically driven physical activity and fitness programs are warranted.

### Objectives

This thesis-by-publication presents a series of studies, which aim to address a number of gaps within the current evidence base. The principal focus of this thesis is the development and evaluation of the ATLAS (*Active Teen Leaders Avoiding Screen-time*) cluster randomised controlled trial (RCT), a school-based program aimed at improving health-related fitness and key health behaviours among adolescent males attending schools in low-income communities. Given emerging evidence of the importance of muscular fitness and movement skill competence for achieving and maintaining good health, this thesis also presents a series of studies aimed at investigating key secondary aims related to these topics. Considering the chronology of the research included within this thesis, and the importance of these studies for providing context to the Primary aim, *Secondary aims 1 and 2* are presented first. The *Primary aim* of this thesis and the remaining secondary aims are then presented, as listed in the order below.

*Secondary aim 1: To systematically review the evidence base regarding the health-benefits of muscular fitness for children and adolescents.*

A systematic literature search of six electronic databases was conducted. Cross-sectional, longitudinal and experimental studies that quantitatively examined the association between muscular fitness and health outcomes among youth populations were included. In total, 110 studies encompassing six health outcomes were included in the review. Meta-analyses were conducted to determine the pooled effect size if at least three studies reported standardised coefficients. Included studies generally demonstrated moderate to low risk of bias. Strong evidence was found for an inverse association between muscular fitness and total and central adiposity, and cardiovascular disease and metabolic risk factors. Strong evidence was also found for a positive association between muscular fitness and bone health and self-esteem. The evidence for an association between muscular fitness and musculoskeletal pain and cognitive ability was inconsistent or uncertain.

*Secondary aim 2: To develop and evaluate a test battery for assessing adolescents' resistance training (RT) movement skill competency.*

The aim of this study was to describe the development and assess test-retest reliability and construct validity of the Resistance Training Skills Battery (RTSB) for adolescents. The RTSB provides an assessment of resistance training skill competency and includes six exercises (i.e., body-weight squat, push-up, lunge, suspended row, standing overhead press and front support with chest touches). A convenience sample of adolescents completed the RTSB on two occasions separated by seven days. Participants also completed the handgrip strength, timed push-up and standing long jump tests to assess the construct validity of the RTSB. The RTSB can reliably rank participants in regards to their resistance training competency and has the necessary sensitivity to detect small changes in resistance training skill proficiency. Finally, the RTSB was found to be an independent predictor of muscular fitness, providing preliminary evidence for construct validity.

*Primary aim: To evaluate the effects of the ATLAS cluster RCT on health-related fitness and RT movement skill competency among adolescent boys attending schools in low-income communities.*

The primary aim of this thesis investigated whether participants randomised to the ATLAS intervention group demonstrated more favourable changes in body composition, muscular fitness and RT movement skill competency, compared with a control group. The ATLAS intervention was evaluated using a cluster RCT in 14 secondary schools located in low-income communities of New South Wales, Australia. In total, 361 adolescent boys were assessed at baseline and were

randomised at the school level to the intervention or control group. The boys were reassessed 8 months later, following the conclusion of the program. Analyses followed intention-to-treat principles. There were no significant intervention effects for body composition (i.e., body mass index [BMI], waist circumference, or percent body fat), or for maximal strength (i.e., hand grip dynamometry). However, compared to boys in the control condition, intervention boys demonstrated greater muscular endurance (i.e., push-up repetitions) and RT skill competency at 8-month follow-up.

*Secondary aim 3: To evaluate the effectiveness of the ATLAS intervention on adolescent boys' physical activity, screen-time, and sugar-sweetened beverage consumption.*

The ATLAS intervention also aimed to address a number of key weight-related behaviours. At 8-month follow-up, adolescent boys randomised to the intervention condition reported less recreational screen-time and SSB consumption, compared with boys in the control group. No significant intervention effects were found for accelerometer-assessed total physical activity (i.e., counts per minute) or moderate-to-vigorous physical activity. Compliance with physical activity monitoring was poor.

*Secondary aim 4: To describe the development and implementation of a smartphone application designed to promote physical activity and reduce screen-time among adolescent boys.*

The ATLAS smartphone app was developed to complement the ATLAS intervention and replace paper-based resources. The app was used for physical activity monitoring, goal setting, and assessment of RT technique. Further, the app provided tailored motivational messages throughout the intervention period. Participants completed process evaluation questionnaires and focus groups, which included questions on the acceptability and usage of the ATLAS app. Seventy percent of boys in the intervention group reported having access to a smartphone or tablet device. Focus group findings suggested that boys' engagement with the smartphone app was limited. Barriers to the implementation and evaluation of the app included limited access to smartphone devices, technical problems with the push notifications, lack of access to usage data and the challenges of maintaining participants' interest in using the app.

*Secondary aim 5: To examine the potential mediating effects of RT movement skill competency on health-related fitness and physical activity.*

RT movement skill development was a key component of the ATLAS intervention. Three separate multi-level mediation models were analysed to investigate the potential mediating effects of RT skill competency on boys' body composition, muscular fitness and physical activity using a product-of-coefficients test. Analyses followed the intention-to-treat principle. Improvements in RT skill competency significantly mediated the effect of the intervention on percent body fat and muscular fitness. No significant mediated effects were found for physical activity.

## **Statement of Contribution**

As the sole PhD student working on the ATLAS cluster RCT, I was closely involved in the design, implementation and evaluation of the study. Further, I liaised closely with the study project manager to manage the host of logistical and administrative tasks required to successfully complete the project. A summary of my contribution to this study is provided below.

### **Program development**

In close collaboration with my supervisors, I was involved in the design and development of a number of components of the ATLAS intervention. Specifically, I was responsible for the development of the project logo and the design of the smartphone application and website used within the program. In addition, I worked with my supervisors to design the components and structure of the school-based physical activity sessions and the two professional learning workshops for teachers. Finally, I was personally responsible for the development of a number of program resources, including the teacher handbook, a screen-time blog page for parents, circuit cards used during the school physical activity sessions, and the parental newsletters.

### **Ethics approval**

I was involved in the drafting of the Principal, teacher, and student/parent information and consent letters. Further, I was personally responsible for drafting and submission of the University (H-2012-0162) and Department of Education and Communities (2012121) ethics applications and ethics variations.

### **Study measures**

I worked in collaboration with my supervisors to decide on the eligibility screening criteria and outcome measures used in the ATLAS study. In addition, I was closely involved in the design and evaluation of a number of measures that were developed for use in this study. Specifically, I contributed to the design and evaluation of the: (i) Resistance Training Skills Battery (RTSB) for adolescents; and (ii) Motivation to Limit Screen-time Questionnaire (MLSQ). These measures have since been published in the peer-reviewed literature (7-9).

### **Recruitment**

I was personally responsible for the identification and recruitment of eligible schools and students. I compiled the list of schools that satisfied our eligibility criteria and contacted the principals at each

of these schools to request their involvement in the study. Where necessary, I met with the school Principal and/or Head Teacher of the Physical Education department to discuss the study. Prior to the commencement of the program, I attended each of the study schools to deliver the eligibility screening questionnaire to all male students in the targeted year group. I personally processed all of the eligibility screening data and compiled the lists of eligible students for each school. In addition, I liaised with the cooperating teachers at the study schools to deliver information sessions to eligible students and to distribute and collect student consent forms.

### **Data collection, entry and management**

During my PhD candidature, I was personally responsible for the development and maintenance of the database for the ATLAS study. Prior to the data collection period, I led a comprehensive training session for the research team to ensure that all assessors understood the assessment protocols. In cooperation with the project manager, I was involved in the organisation of the data collection periods, which were conducted at each of the study schools. In addition, I attended each of the study schools to assist the research team with the collection of baseline and follow-up data. Following data collection, I was responsible for entering, cleaning and de-identifying all data. I performed rigorous data checking procedures to ensure the accuracy of collected data.

### **Program implementation**

I was involved in a number of key aspects of the intervention delivery. First, I was personally involved in the delivery of the two professional learning workshops for teachers, which involved both theoretical and practical activities. In addition, I attended each of the study schools to deliver the researcher-led seminars for students. These interactive seminars were conducted at the start of the program to inform study participants of the key aims and features of the intervention. The first physical activity session at each study school was delivered by a member of the research team, for the purposes of modelling the correct delivery of these sessions. While being observed by a participating teacher, I personally delivered the first physical activity session at a number of intervention schools. Finally, I was personally involved in conducting the observations of the school physical activity sessions. These observations were conducted to assess intervention fidelity and to provide constructive feedback to teachers regarding the session structure and their compliance with the SAAFE teaching principles, which were made familiar to teachers during the professional learning workshops.

### **Data analysis**

With assistance from my primary supervisor, I completed all of the data analysis within the publications in which I am listed as first author (excluding the power calculation in Chapter 5). This included inter-rater reliability analysis and meta-analysis (Chapter 3), scale reliability analysis (Chapter 5), linear mixed model analysis (Chapter 6), and multi-level mediation analysis (Chapter 8).

### **Presentation of study results and awards**

During my PhD candidature I presented study findings at two international and two national conferences. Most recently, my abstract was shortlisted for the ‘Best new investigator’ award at the ‘Be Active’ National Physical Activity conference held in Canberra, Australia in October 2014. I was also a University finalist in the 2012 ‘3 minute thesis’ public speaking competition, having placed first and second at the School of Education and Faculty of Education and Arts levels, respectively. In addition, I was awarded first place in the 2012 Faculty of Education and Arts poster competition (early candidature division).