2014

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

Jordan J. Smith
University of Newcastle

Philip J. Morgan
University of Newcastle

Ronald C. Plotnikoff
University of Newcastle

Kerry A. Dally
University of Newcastle

Jo Salmon
Deakin University

See next page for additional authors

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

Abstract

Introduction The negative consequences of unhealthy weight gain and the high likelihood of pediatric obesity tracking into adulthood highlight the importance of targeting youth who are 'at risk' of obesity. The aim of this paper is to report the rationale and study protocol for the 'Active Teen Leaders Avoiding Screen-time' (ATLAS) obesity prevention intervention for adolescent boys living in low-income communities. **Methods/design** The ATLAS intervention will be evaluated using a cluster randomized controlled trial in 14 secondary schools in the state of New South Wales (NSW), Australia (2012 to 2014). ATLAS is an 8-month multi-component, school-based program informed by self-determination theory and social cognitive theory. The intervention consists of teacher professional development, enhanced school-sport sessions, researcher-led seminars, lunch-time physical activity mentoring sessions, pedometers for self-monitoring, provision of equipment to schools, parental newsletters, and a smartphone application and website. Assessments were conducted at baseline and will be completed again at 9- and 18-months from baseline. Primary outcomes are body mass index (BMI) and waist circumference. Secondary outcomes include BMI z-scores, body fat (bioelectrical impedance analysis), physical activity (accelerometers), muscular fitness (grip strength and push-ups), screen-time, sugar-sweetened beverage consumption, resistance training skill competency, daytime sleepiness, subjective well-being, physical self-perception, pathological video gaming, and aggression. Hypothesized mediators of behavior change will also be explored. **Discussion** ATLAS is an innovative school-based intervention designed to improve the health behaviors and related outcomes of adolescent males in low-income communities.

Disciplines

Education | Social and Behavioral Sciences

Publication Details

Smith, J. J., Morgan, P. J., Plotnikoff, R. C., Dally, K. A., Salmon, J., Okely, A. D., Finn, T. L., Babic, M. J., Skinner, G. & Lubans, D. R. (2014). 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, 37 (1), 106-119.

Authors

Jordan J. Smith, Philip J. Morgan, Ronald C. Plotnikoff, Kerry A. Dally, Jo Salmon, Anthony D. Okely, Tara L. Finn, Mark J. Babic, Geoff Skinner, and David R. Lubans

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

Jordan J. Smith[1], Philip J. Morgan[1], Ronald C. Plotnikoff[1], Kerry A. Dally[1], Jo Salmon[2], Anthony D. Okely[3], Tara L. Finn[1], Mark Babic[1], Geoff Skinner[4], David R. Lubans[1§]

[1]Priority Research Centre for Physical Activity and Nutrition, School of Education, University of Newcastle, Callaghan, New South Wales, Australia
[2]Centre for Physical Activity and Nutrition Research, Deakin University, Burwood, Victoria, Australia
[3]Interdisciplinary Educational Research Institute, University of Wollongong, Wollongong, New South Wales, Australia
[4]School of Design Communication and Information Technology, Faculty of Science and Information Technology, University of Newcastle, Callaghan, New South Wales, Australia
[§]Corresponding author

Email addresses:

JJS: jordan.smith@uon.edu.au

PJM: philip.morgan@newcastle.edu.au

RCP: ron.plotnikoff@newcastle.edu.au

KD: kerry.dally@newcastle.edu.au

JS: jo.salmon@deakin.edu.au

ADO: tokely@uow.edu.au

TLF: tara.finn@newcastle.edu.au

MJB: mark.babic@uon.edu.au

GS: geoff.skinner@newcastle.edu.au

DRL: david.lubans@newcastle.edu.au

Abstract

Background: The negative consequences of unhealthy weight gain and the high likelihood of pediatric obesity tracking into adulthood, highlight the importance of targeting youth who are 'at risk' of obesity. The aim of this paper is to report the rationale, study design and baseline findings from the Active Teen Leaders Avoiding Screen-time (ATLAS) obesity prevention intervention for adolescent boys living in low-income communities.

Methods/Design: The ATLAS intervention will be evaluated using a cluster randomized controlled trial in 14 secondary schools in the state of New South Wales (NSW), Australia (2012 to 2014). ATLAS is an 8-month multi-component, school-based program informed by Self-Determination Theory and Social Cognitive Theory. The intervention consists of teacher professional development, enhanced school-sport sessions, researcher-led seminars, lunch-time physical activity mentoring sessions, pedometers for self-monitoring, provision of equipment to schools, parental newsletters, and a smartphone application and website. Assessments were conducted at baseline and will be completed again at 9- and 18-months from baseline. Primary outcomes are body mass index (BMI) and waist circumference. Secondary outcomes include BMI z-scores, body fat (bioelectrical impedance analysis), physical activity (accelerometers), muscular fitness (grip strength, push-ups, 7-stage sit up test), screen-time, sugared-sweetened beverage (SSB) consumption, resistance training skill competency, daytime sleepiness, subjective well-being, physical self-perception, pathological video gaming, and aggression. Hypothesized mediators of behavior change will also be explored.

Discussion: ATLAS is an innovative school-based intervention designed to improve the health behaviors and related outcomes of adolescent males in low-income communities.

Trial registration: Australian New Zealand Clinical Trials Registry No:

ACTRN12612000978864

Background

The development of youth obesity is driven by a number of complex and interacting factors [1]. While non-modifiable mechanisms are partly to blame, there is strong evidence for the influence of modifiable factors such as physical activity, sedentary behavior and dietary intake in the genesis of youth obesity [1]. Worldwide, there is an estimated 170 million children classified as overweight or obese, with a number of countries reporting combined overweight and obesity prevalence in excess of 20% and as in the US, up to 36% [2]. Similarly, approximately 25% of Australian youth are overweight or obese with higher rates found among those from economically disadvantaged communities [3]. Gender appears to be an additional risk factor, as the prevalence of overweight and obesity among Australian males is higher than females in both adolescents [3] and adults [4]. Consequently, male youth living in disadvantaged communities can be considered a particularly vulnerable group for the development of obesity.

Physical activity confers numerous physiological and psychological benefits during youth including increased bone mineral density, reduced adiposity and higher self-esteem [5]. Furthermore, evidence indicates a dose-response relationship between physical activity and health, in which greater benefits are achieved with increasing levels of activity [5]. Adolescence is a stage during which physical activity declines sharply [6] and global data suggest that 80% of adolescents are not accumulating sufficient activity to accrue associated health benefits [7]. Moreover, physical activity levels are substantially lower among disadvantaged youth [3].

Compounding a reduction in physical activity during adolescence is the amount of time spent in sedentary behaviors. Sedentary behavior is distinct from lack of physical activity and is considered a unique behavioral construct that has an independent relationship with health [8]. The term sedentary behavior incorporates a range of behaviors that require minimal energy expenditure and generally involve sitting or lying down. Of the various sedentary behaviors, screen-based recreation (screen-time) contributes the most to leisure-time sedentary behavior among youth [9]. International guidelines recommend limiting screen-time to less than two hours per day, but 83% of Australian [10], 71% of English, 64% of Canadian and 54% of US adolescent boys exceed these guidelines [11]. Reducing screen-time has been identified as an important strategy for preventing the development of obesity and improving the psychosocial health of young people [12, 13].

Schools have been identified as important institutions for the promotion of health behaviors because they have access to almost all youth and the necessary facilities and personnel [14]. However, school-based obesity prevention interventions targeting adolescents have had mixed success [15]. Our understanding of the factors that contribute to successful interventions is still developing however, it has been recommended that interventions be designed and evaluated among those most at risk [16, 17] such as youth from low-income communities. Furthermore, as both the determinants and the prevalence of obesity are moderated by gender [18], gender-specific programs may be more suitable and efficacious. Methodologically rigorous trials targeting economically disadvantaged groups and tailored for specific genders are clearly warranted. The aim of this paper is to provide the rationale, study description, and baseline findings from the Active Teen Leaders Avoiding Screen-time (ATLAS) program, an innovative obesity prevention intervention for adolescent boys living in low-income communities.

Methods/Design

Study design

The ATLAS intervention will be evaluated using a cluster randomized controlled trial (RCT) (Figure 1). The 8-month intervention will target adolescent males in Year 8 (second year of secondary school) in 14 co-educational, public secondary schools in New South Wales (NSW), Australia. Assessments were conducted at baseline [November-December (Term 4) 2012], and will be repeated post-program [July-September (Term 3) 2013] and at 18-months post baseline [April-June (Term 2) 2014]. Follow-up data collection for the hypothesized mediators will occur during term 2, 2013 (May-June). These data were collected prior to post-program assessments in recognition that for true mediation to occur, the change in cognitions should precede the change in behavior. The design, conduct and reporting of this cluster RCT will adhere to the Consolidated Standards of Reporting Trials (CONSORT) guidelines for group trials [19]. Ethics approval for this study was obtained from the Human Research Ethics Committees of the University of Newcastle, Australia and the NSW Department of Education and Communities. School principals, teachers, parents and students provided informed written consent.

Sample size calculation

A power calculation was conducted to determine the sample size required to detect changes in the primary outcomes (i.e., Body Mass Index [BMI] and waist circumference) at the primary end-point of 9-months [20, 21]. Based on the existing literature, a difference of 0.4 kgm^{-2} was considered to be clinically meaningful in the study sample. Power calculations were based on 80% power with alpha levels set at $p < 0.05$ and assumed a school clustering effect of 0.03 (an intraclass correlation coefficient [ICC] of

.03 was observed in our pilot study) [22]. Baseline post-test correlations (r = .97) and standard deviation (SD = 1.1 kgm^{-2}) estimates were also taken from our pilot study [23]. It was calculated that a study sample of N = 280 students (i.e., 20 students from 14 schools) would provide adequate power to detect a between-group difference of approximately 0.4 kgm^{-2}. Similarly, the proposed sample size would be adequately powered to detect a between-group difference of 1.5cm in waist circumference (r = .96, SD = 11.6 cm). Considering potential drop out among participants of 20% at the primary end point of 9-months [23, 24], we aimed to recruit 350 participants from 14 schools (i.e., 25 from each school).

Setting and participants

The Socio-Economic Indexes for Areas (SEIFA) of relative socioeconomic disadvantage was used to identify eligible secondary schools. The SEIFA index (scale 1 = *lowest* to 10 = *highest*) summarizes the characteristics of people and households within an area and was developed using the following data: employment, education, low income, family breakdown, financial well-being, family type, housing stress, overcrowding, home ownership, family support, lack of wealth (no car or telephone), foreign birth and Indigenous status. Secondary schools located in the Newcastle, Hunter, and Central Coast areas of NSW with a SEIFA index of ≤ 5 (lowest 50%) and an enrolment of at least 100 students in the targeted year group were eligible to participate in the study.

Eligibility screening

Prior to baseline assessments, all male students in the targeted year group at the study schools were asked to complete a two-item screening questionnaire. The questionnaire was used to identify students that may be 'at risk' of obesity based on their physical activity and screen-time behaviors. Students were considered to be 'at risk' if they did not meet the current physical activity and/or screen-time guidelines for Australian adolescents (≥ 2 hours of screen-based recreation and/or < 7 days per week of moderate-to-vigorous intensity physical activity [MVPA] of at least 60 minutes duration per day) [25]. Data from a statewide survey in NSW indicate that approximately 57% and 32.5% of low socio-economic status (SES) males of similar age meet the physical activity and screen-time guidelines, respectively [3].

Blinding and randomization

Recruitment and baseline assessments were conducted prior to randomization. Schools were match-paired, based on their size, SEIFA score and geographic location, and then randomly allocated to the intervention or control group using a computer-based random number producing algorithm. Randomization was performed by a researcher not involved in the current study. Schools will remain in their allocated group for the duration of the study.

Intervention

ATLAS is an 8-month multi-component physical activity and sedentary behavior intervention for adolescent boys ‘at risk’ of obesity. The intervention is based on the Physical Activity Leaders (PALs) RCT [23], a successful pilot study conducted in four secondary schools in the Hunter Region, NSW, Australia. The intervention consists of teacher professional development, researcher-led seminars, enhanced school sport sessions, lunch-time physical activity mentoring sessions, provision of fitness equipment to schools, a smartphone application and website, pedometers for self-monitoring, and parental strategies to reduce screen-time. Table 1 includes the intervention components, behavior change strategies and hypothesized mediators of behavior change.

Theoretical basis of ATLAS

The ATLAS intervention was developed with reference to Self-Determination Theory (SDT) [26] and Social Cognitive Theory (SCT) [27]. Specifically, the intervention is guided by the trans-contextual model of motivation [28], which posits that increasing autonomous motivation for physical activity in one context (e.g., physical education or school sport) will result in increased autonomous motivation for physical activity in other contexts (e.g., after school and on weekends). Consequently, the development of autonomous motivation in school sport, through satisfaction of the three basic psychological needs of autonomy, competence and relatedness, is expected to indirectly influence physical activity behavior during leisure-time [29]. A core component of the ATLAS intervention is the provision of professional development for teachers to ensure that students' basic psychological needs are satisfied in school sport. The basic psychological needs are operationalized through the SAAFE (Supportive, Active, Autonomous, Fair and Enjoyable) teaching principles [30] (Table 2), which were outlined to teachers during the pre-program professional development workshop. These principles are reinforced throughout the intervention period through post-observation feedback to teachers (see process evaluation).

According to Bandura's SCT, perceived self-efficacy (i.e., a belief in one's capability or competence within a specific context) is a central and pervasive determinant of human motivation [31]. In activities in which competence dictates the outcome, such as in a variety of physical activities, self-efficacy plays an important role in an individual's decision to engage in the behavior, the amount of effort expended, and an individual's level of perseverance in the face of difficulty. Considering the decision to incorporate potentially unfamiliar resistance training activities within the ATLAS program, developing self-efficacy was considered an important aspect of the intervention. To enhance self-efficacy, each sport session includes time dedicated to resistance training skill development during which teachers provide feedback on correct resistance training technique. SCT also suggests that for some people certain behaviors (e.g., physical activity) may not in themselves be intrinsically rewarding, regardless of the individual's perceived self-efficacy or their recognition of the expected benefits. Therefore, another set of skills is required to counteract the potentially contravening cognitions associated with the behavior. According to Bandura, self-regulatory skills (i.e., self-monitoring and goal setting) are important contributors to behavioral 'commitment' and hence behavior maintenance [32]. The relevant implication is that changing activity behavior requires more than simply developing self-efficacy. It also requires the development of specific cognitive skills, which will support adherence to physical activity into the future. Pedometers were provided to students to assist in self-monitoring of physical activity while goal setting of physical activity and screen-time behaviors was made available through the smartphone application and website and promoted by teachers.

Professional development for teachers

Professional development for the ATLAS facilitators (physical education teachers) was delivered through two full-day workshops. As an additional incentive, the workshops were approved by the NSW Institute of Teachers as an accredited component of professional development. In NSW schools, teachers must complete 50 hours of professional development within the first five years of their career by attending institute-approved courses. While this does not apply to all teachers involved in ATLAS, teachers that are within their first 5 years of service are able to claim 12 hours of professional development time for the two workshops attended. The first workshop was conducted in December 2012 prior to the commencement of the intervention. It provided a background to youth obesity prevention and familiarized teachers with the intervention components (i.e., intervention strategies, behavioral messages, session structure and observations) and the SAAFE teaching principles. To further educate the teachers about the SAAFE principles, the first ATLAS sport session at each study school was delivered by a member of the research team (DRL, PJM, or JJS). Teachers were asked to observe the session and complete the SAAFE evaluation checklist. The checklist outlined specific elements of the session, which apply to each of the principles (see process evaluation). The second workshop was conducted mid-program in April 2013. In this workshop, an overview of the baseline results was provided as well as an outline of SDT and its applications in physical education and school sport.

Intervention components and delivery

Overview. The intervention is being delivered over two school terms (i.e., 20 weeks) and focuses on promoting lifetime (e.g., resistance training) and lifestyle physical activities (e.g., walking and riding to school). ATLAS is aligned with current physical activity guidelines, which include a recommendation to engage in muscle and bone strengthening physical activities on at least three days per week [33]. In addition to a focus on developing muscular fitness, the intervention also aims to increase low-intensity incidental activity. Non-Exercise Activity Thermogenesis (NEAT), the energy expended through all physical activities outside of purposeful exercise, contributes substantially to overall daily energy expenditure [34]. A reduction in NEAT, potentially through increased sedentariness during discretionary time and a reduction in levels of active transport has been implicated in the rise in obesity in developed countries [35]. ATLAS encourages participants to increase their NEAT and suggests strategies such as choosing active rather than passive transport options, using stairs instead of lifts where possible, and breaking up sedentary time. The intervention also aims to reduce consumption of sugar-sweetened beverages (SSB's). Regular consumption of SSB's, including carbonated soft drinks (i.e., soda), cordials, and refined fruit juices may contribute substantially to overall daily energy intake and evidence suggests that SSB consumption is associated with higher adiposity among youth [36]. In addition, adolescents may have more control over this dietary outcome as other aspects of diet quality (e.g., fruit and vegetable intake) may be predominantly determined by parental influences (i.e., grocery purchasing and meal preparation). This is supported by the findings from the PALs pilot study, in which there was a significant intervention effect for SSB intake but not for consumption of fruit and vegetables despite each of these dietary outcomes being targeted [23]. The intervention promotes four key messages relating to energy balance-related behaviors: (i) walk whenever you can; (ii) get some vigorous physical activity on most days; (iii) reduce your recreational screen-time; and (iv) drink more water and less sugary drinks. Students are provided with information regarding these behavioral messages during the researcher-led seminars and teachers reinforce them during the closure section of each sport session.

Enhanced school sport sessions. School sport, while available in a variety of formats [37], is mandatorily provided to junior school students in NSW schools on a weekly basis and occurs in addition to regular physical education classes. The ATLAS enhanced sport sessions occur during the regularly scheduled period allocated to school sport at each school. While the time of day and the day of the week for the sport sessions vary between schools, each school receives a similar amount of school sport time in a normal week. School sport sessions are delivered by teachers at the study schools, at no cost to students, and involve elastic tubing resistance training; fitness challenges, aerobic- and strength-based activities, and modified ball games. In low-income communities in particular, the cost of many school sport activities can be a considerable barrier to participation [37]. The sport sessions follow a predetermined structure, which was outlined to teachers during professional development prior to the start of the intervention. The sessions are organized into the following format: (i) warm up: movement-based games and dynamic stretches; (ii) resistance training skill development: Gymstick™ and body weight exercise circuit; (iii) fitness challenge: short duration, high intensity Crossfit™-style workout performed individually with the aim of completing the workout as quickly as possible; (iv) Games: minor strength and aerobic-based games (e.g., sock wrestling, tag-style games) and small sided ball games that maximize participation and active learning time (e.g., touch football); and (v) cool down: static stretching and discussion of ATLAS messages. Finally, during the second school term, each school will receive one visit during their regularly scheduled sport session from a practicing fitness instructor (i.e., personal trainer). The fitness instructor will deliver the session while the teacher observes and completes the session observation checklist. This component was included to provide additional professional development for teachers.

Sessions will include structured Rough-and-Tumble Play activities as part of the strength-based games section. These are vigorous activities that on the surface may appear to be aggressive except for the playful context in which they take place and include activities such as wrestling, grappling and tumbling [38]. Rough-and-tumble play behavior occurs among a number of mammalian species and is believed to be an important experience for the affective and cognitive development of youth (especially for boys) [39]. Furthermore, rough-and-tumble play experiences are thought to contribute to feelings of relatedness and provide opportunities for youth to develop key self-regulation skills thereby reducing the likelihood of using aggressive behaviors in the future [39, 40].

Lunch-time leadership sessions. During the second school term students will have the opportunity to participate in physical activity mentoring sessions. Study participants will be asked to participate in the organization and conduct of supervised physical activity sessions during six lunchtime periods, approximately 20 minutes in duration. Students will be required to partner with a younger peer and provide corrective feedback during the conduct of a Gymstick™ and bodyweight resistance-exercise circuit.

Smartphone application (app). A smartphone app was developed to support the delivery of the intervention. The application was made available on both iOS and

Android platforms. To cater for those without access to a smartphone device, the same functions were available via the ATLAS website, which was developed for the current study. Research suggests that 73% of 12-14 year olds [41] and 90% of adolescents over the age of 15 [42] own mobile devices (i.e., smartphones or tablets). Smartphone ownership among youth has accelerated and doesn't appear to be moderated by SES [43]. Functions of the application/website include: (i) physical activity monitoring through recording daily step counts from pedometers; (ii) recording and review of fitness challenge results; (iii) peer assessment of resistance training skill competency; (iv) goal setting for screen-time and physical activity; and (v) tailored motivational messaging. At the commencement of the intervention, students were asked to select two reasons that motivated them most to be physically active from a list of four possible reasons: (i) to look good; (ii) to improve my health; (iii) to do better at school; and (iv) to spend time with friends. Once the student submitted their preferences, messages based on the two reasons they selected were sent via 'push notifications' through the app. The messages were written in vernacular 'text speak' in order to connect with students (e.g., *Exercise helps u look fit and feel good. How much exercise have u done 2day?*).

Parent/caregiver strategies to reduce screen-time. During the study period, four newsletters (two per school term) will be mailed to the parents/caregivers of study participants. Each newsletter will contain information on the consequences of excessive screen-time among youth, potential strategies to reduce their adolescent's screen-time (e.g., removal of screen devices from the bedroom, screen-time curfew), and strategies for preventing conflict when discussing screen-time issues. In addition, the first newsletter will include a behavior contract and list of potential screen-time rules and the third newsletter will include a physical activity and fitness report card, which provides individualized results from baseline assessments. Reference values for each test will be provided to give context to the results.

Control group: To prevent compensatory rivalry and resentful demoralization [44], the control schools will be provided with a condensed version of the program following the 18-month assessments. The condensed version of the program will include the professional learning workshops for teachers and resources to conduct the enhanced school sport sessions. As was done for intervention schools, an equipment pack valued at approximately $1000 AUD (including pedometers, elastic tubing devices, boxing gloves, focus pads and hanging gym handles) will also be provided based on individual school requirements.

Outcomes

A protocol manual with specific instructions for conducting all assessments was used by research assistants during baseline data collection and will be used during follow-up assessments to ensure consistency. Questionnaires were completed in exam-like conditions using an online survey with Apple iPads and physical assessments were conducted in a sensitive manner (e.g., weight and waist circumference measured out of the view of other students). Demographic information including age, ethnicity, language spoken at home, residential postcode and parents'/caregivers' highest level of education was collected at baseline. A range of primary and secondary outcomes and hypothesized mediators of behavior change were also measured. A link to an online survey was also emailed to parents/caregivers of study participants to complete. If the survey was not completed within two weeks of distribution (potentially due to a lack of internet access or computer competency limitations) a paper copy and reply paid envelope was posted to the parent/caregiver's nominated postal address.

Primary outcomes

Height and weight. Weight was measured to the nearest 0.1kg without shoes, in light clothing using a portable digital scale (Model no. UC-321PC, A&D Company Ltd, Tokyo Japan) and height was recorded to the nearest 0.1 cm using a portable stadiometer (Model no. PE087, Mentone Educational Centre, Australia). BMI was calculated using the standard equation (weight[kg]/height[m]^2) and BMI z-scores were calculated using the 'LMS' method [45].

Waist circumference. Waist circumference was measured to the nearest 0.1cm against the skin using a non-extensible steel tape (KDSF10-02, KDS corporation, Osaka, Japan) in line with the umbilicus. Waist circumference-to-height ratio was calculated using the equation (Waist circumference[cm]/height[cm]). Waist circumference-to-height ratio has been shown to be a better predictor of adiposity than BMI in a large sample of children and adolescents [46].

Secondary Outcomes

Body fat percentage. The Imp™ SFB7 bioelectrical impedance analyzer (BIA) was used to determine percentage body fat, fat free mass and fat mass. The Imp™ SFB7 [47] is a multi-frequency, tetra polar bioelectrical impedance spectroscopy device and has acceptable test-retest reliability in adolescents (ICC [95%CI] = .95 [.90 to .97]) [48].

Physical activity. Physical activity was assessed using triaxial Actigraph™ accelerometers (model GT3X+), worn by participants during waking hours for seven consecutive days, except while bathing and swimming. Trained research assistants, following standardized accelerometer protocols [49] fitted the monitors and explained the monitoring procedures to students. Data were collected and stored in 5-second epochs. Valid wear time was defined as a minimum of three days with at least 10 hours (i.e., 600 minutes) of total wear time recorded. Non-wear time was defined as 30 minutes of consecutive zeros. There is some consensus in the literature regarding the appropriate duration of wear time to define a 'valid day', with general agreement that 10 hours is the most suitable protocol [50]. Furthermore, a recent systematic review identified 10 hours of wear time as the most commonly used protocol for defining a valid day in adolescent studies. The mean activity counts per minute (CPM) were calculated, while the thresholds for activity counts proposed by Evenson et al. [51] were used to categorize physical activity into sedentary, light, moderate, and vigorous intensity activity. Moderate and vigorous activity is summed to produce an MVPA variable.

Muscular fitness. The 90-degree push-up test was used as a measure of upper body muscular endurance [52]. Testing procedures were explained to the participants prior to the test. The test began with participants in the push-up position with hands and toes touching the floor, arms approximately shoulder width apart and back straight. Participants lowered themselves to the floor in a controlled manner until a 90-degree angle was formed at the elbow then pushed back up. Push-ups were performed in time with a metronome, set at 40 beats per minute, allowing one push-up every three seconds. The test concluded when participants either failed to lower themselves to the required depth on three non-consecutive repetitions (warnings verbalized by assessor), failed to maintain the movement with adequate form in time with the metronome, or upon volitional failure. Assessors did not provide verbal encouragement during the conduct of the test. This test has acceptable test-retest reliability in adolescents (ICC [95%CI] = .90 [.80 to .95])[48].

The 7-stage abdominal strength test was used as a measure of abdominal muscular strength. A detailed explanation of each stage is outlined by Lubans et al. [48]. Briefly, this test requires participants to perform one repetition of the sit-up at stages of increasing difficulty. The highest stage in which a participant can successfully perform the sit-up is recorded as their score. Participants began in a supine position, with legs bent to form a 90-

degree angle at the knee. They were asked to perform one repetition in a controlled manner, without using a twisting or rocking movement to assist. Participants were allowed a second attempt upon failure of a stage following a 5-10 second rest period. Assessors did not provide verbal encouragement during the conduct of the test. Test-retest reliability was shown to be satisfactory (ICC [95%CI] = .91 [.81 to .96]) in a sample of adolescents [48].

Strength of the hand and forearm muscles was assessed using a handgrip dynamometer (SMEDLEY'S dynamometer TTM, Tokyo, Japan). As demonstrated by Ortega et al. [53], there is an optimal grip span for grip strength measurements which is partly influenced by the hand size of the participant being assessed. Therefore, the grip-span on the dynamometer was adjusted to suit the hand size of the participant prior to their performance. Subjects were asked to squeeze the dynamometer continuously as hard as possible for three seconds with the elbow in full extension down by the side of the body. The test was performed three times each for the left and right hands, alternating hands after each trial. A recent systematic review identified the hand grip test as a valid test to assess upper body maximal strength among youth [54]. In addition, grip strength testing has demonstrated acceptable test-retest reliability among adolescents [55]

Resistance training skill competency. Resistance training skill competency was assessed using video analysis of the Resistance Training Skills Battery (RTSB) [56]. The test requires participants to perform six movements (lunge, push-up, overhead press, front support with chest touches, squat, and suspended row) considered to be the foundation for more complex exercises used in resistance training programs. Each skill consists of four or five performance criteria and is scored by adding the total number of criteria successfully demonstrated. Each skill is performed twice, resulting in a total score of either 8 or 10 depending on the number of performance criteria. An overall gross resistance training skill quotient (RTSQ) is created by adding the six scores (possible range 0 to 56). Students were provided with a demonstration of each skill prior to being assessed. They were asked to perform two sets of four repetitions of each skill and were allowed a rest period of up to 15 seconds between sets. The assessor did not provide verbal encouragement or skill specific feedback during the performance of the skill. The RTSB has demonstrated satisfactory construct validity and test-retest reliability (ICC [95%CI] = .88 [.80 to .93]) among a sample of adolescents [56].

Student questionnaire

Recreational screen-time. A modified version of the Adolescent Sedentary Activity Questionnaire (ASAQ) [57] was used to determine time spent in screen-based recreation. The ASAQ requires subjects to self-report the total time spent engaged in a variety of recreational screen behaviors (e.g., watching television, playing video games, using the computer). Total screen-time is then determined as the sum of time spent in each screen behavior. However, evidence suggests that youth often use multiple screen devices simultaneously (e.g., surfing the internet on a laptop while watching television) [58, 59]. Although respondents are asked to consider media-multitasking when completing the ASAQ, scoring adjustments are only made if participants' screen-time values are implausible. The modified ASAQ used in the current study required respondents to report the 'total time' spent sitting using screens (of any kind) for anything other than homework on each day of the week. Therefore, rather than providing data on time spent using individual screen devices and summing the times for each, this measure instead provides data on 'total screen-time'. It is believed that this method will provide a more accurate assessment of total screen-time by addressing the issue of screen multitasking [58, 59]. Students were also asked to list their three favorite computer/video games.

Sugar-sweetened beverage consumption. Two items from the NSW Schools Physical Activity and Nutrition Survey (SPANS) [3] were used to assess consumption of sugar-sweetened beverages (SSB's). Students were asked to report how many glasses of fruit-based drinks and soft drinks/cordial they consumed on a 'usual' day (range = *none* to *7 or more per day*).

Physical self-concept. Items from the perceived strength subscale of the Physical Self-Description Questionnaire (PSDQ) [60] were used. Students were asked to respond on a 6-point scale (*1 = False, to 6 = True)* how true each statement was for them (e.g., *I am a physically strong person*). The PSDQ is a valid method for measuring physical self-concept [60] and the perceived strength subscale has satisfactory reliability in the current sample (Chronbach's $\alpha = .69$) [60].

Subjective well-being. Diener and colleagues' psychological flourishing scale [61] was used to measure subjective well-being. Students responded on a 7-point scale (*1=Strongly disagree, to 7=Strongly agree*) to how much they agreed with each statement relating to indicators of social well-being (e.g., *I lead a purposeful and meaningful life*). A composite score was created by summing the scores for each item (possible range 8 to 56). A high score represents a person with many psychological resources and strengths. This scale has demonstrated satisfactory construct validity [61], and acceptable reliability in the current sample (Chronbach's $\alpha = .88$).

Pathological video gaming. Gentile's pathological video gaming scale [62] was used to classify participants as problem gamers. The scale contains 11 questions pertaining to cognitions and behaviors indicative of pathological gaming (e.g., *Have you played video games as a way of escaping from problems or bad feelings?*). Students responded either *Yes (= 1)*, *No (= 0)*, or *Sometimes (= 0.5)* to each question. A sum total of ≥ 6 qualifies a subject as a pathological gamer. This scale has demonstrated satisfactory construct validity in a large sample of youth aged 8-18 years [62] and has shown acceptable reliability in the current sample (Chronbach's $\alpha = .76$).

Aggression. Aggressive behavior was assessed using an aggression scale designed for young adolescents [63]. Students were asked to report how many times in the last week they engaged in 11 specific aggressive behaviors (e.g., *I threatened to hit or hurt someone*). Responses range from 0 to 6 or more times per week for each aggressive behavior. Items were summed to produce a total aggression score (possible range 0 to 66). This scale has demonstrated satisfactory content and construct validity in adolescent males [63] and has shown acceptable reliability in the current sample (Chronbach's $\alpha = .90$).

Daytime sleepiness. Three items from the Pediatric Daytime Sleepiness Scale [64] were used to measure daytime sleepiness. Students responded on a 4-point scale *(0 = never, to 4 = always)* to how often they experienced symptoms characteristic of insufficient or inadequate sleep (e.g., *How often do you fall asleep or get drowsy during class periods?*). Items were summed to produce a total daytime sleepiness score (possible range 0 to 12). While the internal consistency of these items in the current sample is slightly lower than what is commonly deemed desirable (Chronbach's $\alpha = .63$), this is likely the result of only three items being used.

Hypothesized mediators

The role of psychological theories and cognitive mediators in the effectiveness of school-based interventions has been identified as a gap in the current research literature [65, 66]. Further testing of potential cognitive mediators in methodologically rigorous trials may help elucidate specific intervention strategies that contribute to achieving a significant effect. The hypothesized mediators, including example items and scale reliabilities, are listed in Table 3.

Motivation in school sport. Motivational regulations for school sport outlined in SDT were assessed with an adapted scale used by Goudas et al. [67]. The original items were designed for use in the physical education context, which were modified to assess motivation for school sport. Students responded to 20 items on a 7-point scale (*1 = not at all true, 7 = very true*).

Psychological needs satisfaction. 19 items from existing validated scales [68, 69] were used to assess autonomy (i.e., choice, volition and internal perceived locus of causality), competence and relatedness needs satisfaction during school sport. Items designed for use within the physical education context were adapted to apply to school sport. Students responded on a 7-point scale (*1 = not at all true, 7 = very true*).

Motivation to limit screen-time. The Motivation to Limit Screen-time Questionnaire (MLSQ) [70] was developed to assess participants' motivation for limiting time spent engaged in sedentary screen-based recreation. The MLSQ contains nine questions relating to the three broad motivational regulations outlined in SDT (i.e, autonomous motivation, controlled motivation, and amotivation) [26]. The subscales are weighted to create a single continuous variable known as the relative autonomy index which is calculated using the following: RAI = Σ([Autonomous x 2] + [Controlled x -1] + [Amotivation x -2]). A positive score represents autonomous motivation to limit screen-time. The MLSQ has demonstrated satisfactory construct validity and test-retest reliability (ICC [95%CI] = .81 [.66 to .89]) in adolescent boys [70].

Screen-time rules: Screen-time rules from a survey developed by Ramirez et al. [71] were adapted for the present study. Students responded either *No*, *Sometimes*, or *Yes* for each of six items relating to screen-time rules within their family home using the common stem: *In your home do your parents/caregivers have the following rules about screen-use?* The items were originally designed to apply specifically to TV/DVD or computer use and were therefore adapted to apply to all screen-time devices (e.g., *No screen-time before homework*). Test-retest reliability for these items is fair (κ = .43 to

.61) [72] among adolescents and the presence of these rules has been shown to be significantly inversely associated with screen-time [71].

Physical activity behavioral strategies. Students responded to six items developed by Dewar et al. [73] for use with adolescents. The items relate to the use of social-cognitive strategies for successfully engaging in physical activity. Students were instructed to respond to each item on a 5-point scale (*1 = never to 5 = always*). These items have acceptable test-retest reliability in adolescents (ICC [95%CI] = .91 [.88 to .93]) [73].

Parent/caregiver questionnaire

Parents/caregivers of study participants were provided with items from the Children's Leisure Activities Study Survey [74]. Parents reported the time they spent in a 'typical' week engaged in moderate and vigorous physical activity and also reported the amount of time per week spent watching television or videos and using the computer. In addition, parents responded to eight items relating to physical activity role modeling and support (e.g., *I use my behavior to encourage my child to be physically active*). Parents reported their screen-time rules in the family home using the same items as those provided to their sons [71] and were asked if their son has a television in his bedroom. Finally, parents reported the number of hours of sleep their child usually receives per night. Basic demographic information including gender, country of birth, language spoken at home and highest educational level achieved was also collected.

Process evaluation

A range of process data will be collected to complement the outcome data. Process measures include: (i) student attendance at sport sessions (i.e., percentage attendance); (ii) student leadership accreditation (i.e., number of students who satisfy the accreditation guidelines); (iii) teacher satisfaction with professional learning workshops (using workshop evaluation questionnaires); (iv) parental involvement using a process evaluation questionnaire (e.g. reading newsletters and using suggested strategies to reduce screen-time); (v) teacher, student and parent satisfaction with all intervention components (using program evaluation questionnaires at the completion of the study); and (vi) intervention fidelity (determined by 4 x sport session observations at each school by the research team). The observations are completed with reference to an observation checklist developed for the intervention. The checklist is used to determine whether the sessions adhered to the proposed session structure (i.e., 'Yes' or 'No' for each component of the session) and also the degree to which the session demonstrated the SAAFE teaching principles. For each of the five SAAFE principles, there are three or four statements pertaining to how the principle should be applied within a session (e.g., *Supportive – teacher provides individual skill specific feedback*). The degree to which each principle is implemented is determined by assigning a score on a 5-point scale for each statement (*1 = not at all true, 5 = very true)*. Feedback is given to the teachers at the conclusion of the sport session including strengths of the session and areas for improvement. Teachers used the same checklist to observe the researcher-led session conducted at the beginning of the intervention.

Statistical methods

Statistical analyses of the primary and secondary outcomes will be conducted with linear mixed models using IBM SPSS Statistics for Windows, Version 20.0 (2010 SPSS Inc., IBM Company Armonk, NY) and alpha levels will be set at $p < 0.05$. The mixed models will be specified to adjust for the clustered nature of the data and will follow the intention-to-treat principle. Potential moderators of the intervention effects (e.g., ethnicity, socio-economic status, baseline weight status, and baseline fitness level) will be explored using linear mixed models with interaction terms. Differences between completers and those who drop out of the study will be examined using Chi-square and independent samples t-tests. Hypothesized mediators of physical activity behavior change will be examined using multilevel linear analysis and a product-of-coefficients test that is appropriate for cluster randomized controlled trials [75].

Results

The study design and flow can be found in Figure 1. Twenty-two public secondary schools in the Hunter and Central Coast, NSW were identified as eligible for inclusion in the study based on their SEIFA score. An information and consent form was sent to the principal of each school followed by contact from a member of the research team. Of the schools that were contacted, 14 consented to participate and 4 declined. The required number of schools was reached prior to a decision from the remaining two schools. Eligibility screening was completed by 997 students, of whom 850 (85%) were considered eligible. In total, 361 participants from 14 secondary schools were assessed at baseline. Due to the nature of the study we are unable to report an accurate consent rate (i.e., percentage of consent letters returned divided by the number of consent letters distributed). However, the recruitment target of 25 students per school was achieved in seven of the 14 schools and five of the remaining seven schools were close to the target (i.e., ≥ 22 students). The final recruitment rate was 94%. The baseline characteristics of the study sample can be found in Table 4. The majority of participants was born in Australia (94.9%), spoke English at home (95.7%) and identified their cultural background as Australian (77.1%). The proportion of subjects classified as overweight and obese was 21.3% and 14.4% respectively, and the mean(SD) waist circumference was 76.4(12.4)cm.

Valid physical activity data were available for 253 (70.1%) participants. Of those who provided valid data, 51% met the national physical activity recommendation of achieving at least 60 minutes of MVPA per day (averaged across valid days). In addition, 58.5% of participants met the recreational screen-time guideline of less than 2 hours per day. Finally, the proportion of participants consuming more than 2 glasses of SSB (i.e., carbonated soft drinks/cordial and fruit-based drinks combined) per day was 93.8%.

Discussion

Adolescence is a life phase crucial to future health and has been described as a critical period for the prevention of obesity [76, 77]. Supporting this contention is strong evidence that obesity tracks into adulthood [78]. While the physiological benefits of maintaining a healthy weight across the lifespan are numerous [79], the most immediate benefits of improving the antecedents of obesity may be psychological. Increased physical activity has been linked to short-term improvements in self-esteem in young people [80, 81] and, while more prospective and experimental data are required, evidence suggests that excessive screen-time is associated with lower self-esteem [82] and may even increase the risk of depression [83, 84]. Consequently, increasing physical activity and reducing screen-time may be important for improving both the short- and long-term mental health of young people.

It has been noted in the literature that interventions among youth should be differentiated on the basis of gender and SES [22]. While a number of studies have targeted minority youth [85, 86] and youth from low-income communities [22, 87], to the authors' knowledge, apart from the PALs pilot study [23] this is the first intervention to specifically target adolescent boys. Previous school-based interventions have demonstrated promise but results have been inconsistent. The Dutch Obesity intervention in Teenagers (DOiT) program [87] resulted in short-term improvements in body composition for boys and girls [88], but after 20 months the improvements observed among boys were no longer significant [89]. By contrast, the NEAT Girls program found a significant between-group difference of two percent body fat at 24-months [90], despite non-significant findings immediately post-program at 12-months [24]. Further testing through interventions using rigorous methodologies are required to determine the effectiveness of targeted and tailored interventions among youth.

Considering the limited impact of previous obesity prevention interventions [91], it is important that researchers identify potential areas for improvement. In addition to targeting 'at risk' groups, another area for improvement is the method used for participant identification and recruitment. We used a screening questionnaire to identify eligible participants based on their physical activity and screen-time behaviors. All male students in the targeted year group available on the assessment day were screened for eligibility. Previous intervention studies have utilized physical education teachers to select participants [22, 23] however; this method is relatively subjective and may be influenced by teacher bias. By screening students based on self-report of their physical activity and screen behaviors we were able to identify and target students exhibiting behaviors that contribute to weight status in youth [92, 93]. Furthermore, this method is replicable and relatively easy to administer.

The baseline prevalence of combined overweight and obesity in the ATLAS sample was 36%, which is similar to that reported in the PALs pilot study [23], but somewhat lower than the 43% observed in a recent intervention targeting low SES adolescent girls in the same areas of NSW [22]. Importantly, the prevalence of overweight and obesity in the ATLAS sample was approximately 12% higher than the statewide average for low SES males of similar age [3]. The comparably high proportion observed in the present sample provides additional evidence that our methods were successful in recruiting the targeted participants.

Participants spent an average of 63 minutes per day engaged in MVPA but due to the variability in MVPA between participants (range = 107 minutes) this corresponded to only 51% of students meeting national physical activity guidelines (i.e. ≥ 60 minutes of MVPA per day). However, it must be noted that in order to be 'meeting guidelines' an individual must achieve the required 60 minutes of MVPA on 'every day' of the week [25]. Only 3 days of monitoring was required for participants to be included in the present analysis and the quantity of daily MVPA was based on the average of valid days. While this gives us an 'indication' of typical daily physical activity, in most cases meeting guidelines is not determined from seven days of monitoring and therefore we cannot be certain that the value obtained is representative of an entire week's physical activity. It is entirely possible that a participant providing usable data was more (or less) active on the days in which the monitor was not worn. Despite these limitations, accelerometry is an objective measure of physical activity and is superior to many still widely used self-report instruments.

The proportion of ATLAS students meeting national screen-time guidelines was 58.5%. This is almost 10% lower than that observed in a representative sample of similar age youth [3]. However, the difference is likely to be in part the result of our measurement method, which is thought to provide a more conservative estimate for total screen-time. Interestingly, approximately 11% of the sample qualified as pathological or 'problem' video gamers. In a national study of 8-18 year olds from the U.S, Gentile [62] reported a similar prevalence of pathological gaming for boys. While this proportion may be rather small, it is important to note that compared to non-pathological gamers, pathological gamers do poorer in school, have more health problems and are more likely to report feelings of 'addiction' [62]. Despite the seemingly low number of cases, the potential severity of these consequences may warrant further attention to ‘problem gaming’ in youth screen-time discourse.

The link between muscular fitness and health is an emerging area of research, with recent investigations confirming muscular fitness is associated with a variety of health outcomes [53]. Evidence suggests that, among youth, muscular fitness levels (i.e., strength, power, and muscular endurance) are related to indices of bone health [94], cardiovascular disease risk factors [95], and may also be protective against future mental health problems and risk of suicide [96]. Consequently, there is a strong rationale for building competence in activities that develop muscular fitness among youth. A novel component of the ATLAS intervention is the focus on muscular fitness improvement through the use of resistance training. Perceived strength and muscularity have been identified as important contributors to self-esteem among young males [97, 98]. Targeting the muscular fitness domain may therefore represent an opportunity to engage boys who may otherwise fail to value physical activity. ATLAS aims to develop competence in a range of basic resistance training activities enabling participation in health-enhancing activity both in the short term and into the future.

Conclusion

This paper has outlined the rationale, methods and baseline results from the ATLAS intervention for adolescent boys living in low-income communities. ATLAS is an innovative, school-based obesity prevention intervention targeting key energy balance-related behaviors among a sample of adolescent boys at risk of obesity and associated health problems. The intervention has a strong theoretical foundation and incorporates a number of novel strategies to increase physical activity, reduce screen-time and reduce intake of SSB’s. In addition to providing evidence on the modifiability of key weight-related behaviors among adolescent boys, the ATLAS intervention will improve our understanding of the role of psychological and cognitive mechanisms of behavior change through the assessment of a number of potential mediators. Furthermore, ATLAS will inform the development of future interventions among youth.

List of abbreviations

ATLAS = Active Teen Leaders Avoiding Screen-time; BMI = Body Mass Index; RCT = Randomized Controlled Trial; PALs = Physical Activity Leaders; MVPA = Moderate-to-Vigorous Physical Activity; SDT = Self-Determination Theory; SCT = Social Cognitive Theory; SPANS = Schools Physical Activity and Nutrition Survey; ICC = Intraclass Correlation Coefficient; SES = Socio-Economic Status; SEIFA = Socio-Economic Indexes For Areas.

Competing interests

The authors have no competing interests to declare.

Authors' contributions

DRL, PJM, RCP and KD obtained funding for the research. All authors contributed to developing the protocols and reviewing, editing, and approving the final version of the paper. DRL, PJM, RCP, KD, JS, ADO and JJS developed the intervention materials. TLF, MJB and JJS are responsible for data collection and cleaning. DRL is the guarantor and accepts full responsibility for the conduct of the study and the integrity of the data. All authors have read and approved the final manuscript.

Acknowledgements and Funding

This project is funded by an Australian Research Council (ARC) discovery grant. ARC funding number: DP120100611. RCP is supported by a National Health and Medical Research Council (NHMRC) Senior Research Fellowship. JS is supported by a NHMRC

Principal Research Fellowship (APP1026216) and ADO is supported by a National Heart Foundation of Australia Career Development Fellowship (CR11S 6099).

References

1. Han JC, Lawlor DA, Kimm S: **Childhood obesity**. *Lancet* 2010, **375**(9727):1737-48.

2. Swinburn BA, Sacks G, Hall KD, McPherson K, Finegood DT, Moodie ML *et al*: **The global obesity pandemic: shaped by global drivers and local environments**. *Lancet* 2011, **378**(9793):804-14.

3. Hardy LL, King L, Espinel P, Cosgrove C, Baumanm A: **NSW Schools Physical Activity and Nutrition Survey (SPANS) 2010: Full Report.** Sydney, NSW Ministry of Health.

4. Cameron AJ, Welborn TA, Zimmet PZ, Dunstan DW, Owen N, Salmon J *et al*: **Overweight and obesity in Australia: the 1999-2000 Australian diabetes, obesity and lifestyle study (AusDiab)**. *Med J Aust* 2003, **178**(9):427-32.

5. Janssen I, LeBlanc AG: **Review Systematic review of the health benefits of physical activity and fitness in school-aged children and youth**. *Int J Behav Nutr Phy* 2010, **7**(40):1-16.

6. Sallis JF: **Age-related decline in physical activity: a synthesis of human and animal studies**. *Med Sci Sport Exer* 2000, **32**(9):1598-600.

7. Hallal PC, Andersen LB, Bull FC, Guthold R, Haskell W, Ekelund U: **Global physical activity levels: surveillance progress, pitfalls, and prospects**. *Lancet* 2012.

8. Dunstan D, Barr E, Healy G, Salmon J, Shaw J, Balkau B *et al*: **Television viewing time and mortality the australian diabetes, obesity and lifestyle study (AusDiab)**. *Circulation* 2010, **121**(3):384-91.

9. Salmon J, Tremblay MS, Marshall SJ, Hume C: **Health risks, correlates, and interventions to reduce sedentary behavior in young people**. *Am J Prev Med* 2011, **41**(2):197-206.

10. Morley B, Scully M, Niven P, Baur LA, Crawford D, Flood V *et al*: **Prevalence and socio-demographic distribution of eating, physical activity and sedentary behaviours among Australian adolescents**. *Health Promot J Aust* 2012, **23**(3):213-18.

11. Currie C, Zanotti C, Morgan A, Currie D, Looze Md, Roberts C *et al*: **Social determinants of health and well-being among young people. Health Behaviour in School-aged Children (HBSC) study: International report from the 2009/2010 survey**. Copenhagen: WHO Regional Office for Europe; 2012.

12. Tremblay MS, LeBlanc AG, Kho ME, Saunders TJ, Larouche R, Colley RC *et al*: **Systematic review of sedentary behaviour and health indicators in school-aged children and youth**. *Int J Behav Nutr Phy* 2011, **8**(1):98-119.

13. Barnett TA, O'Loughlin J, Sabiston CM, Karp I, Bélanger M, Van Hulst A *et al*: **Teens and screens: the influence of screen time on adiposity in adolescents**. *Am J Epidemiol* 2010, **172**(3):255-62.

14. Wechsler H, Devereaux RS, Davis M, Collins J: **Using the school environment to promote physical activity and healthy eating**. *Prev Med* 2000, **31**(2):S121-S37.

15. Brown T, Summerbell C: **Systematic review of school□based interventions that focus on changing dietary intake and physical activity levels to prevent childhood obesity: an update to the obesity guidance produced by the National Institute for Health and Clinical Excellence**. *Obes Rev* 2009, **10**(1):110-41.

16. Cavill N, Biddle S, Sallis J: **Health enhancing physical activity for young people: Statement of the United Kingdom Expert Consensus Conference**. *Pediatr Exerc Sci* 2001, **13**(1):12-25.

17. Cale L, Harris J: **School-based physical activity interventions: effectiveness, trends, issues, implications and recommendations for practice**. *Sport Educ Soc* 2006, **11**(4):401-20.

18. Singh GK, Kogan MD, Van Dyck PC, Siahpush M: **Racial/ethnic, socioeconomic, and behavioral determinants of childhood and adolescent obesity in the United States: analyzing independent and joint associations**. *Ann Epidemiol* 2008, **18**(9):682-95.

19. Campbell MK, Elbourne DR, Altman DG: **CONSORT statement: extension to cluster randomised trials**. *Brit Med J* 2004, **328**(7441):702-08.

20. Carlin JB, Hocking J: **Design of cross□sectional surveys using cluster sampling: an overview with Australian case studies**. *Aust NZ J Publ Heal* 1999, **23**(5):546-51.

21. Howell D: **Statistical Methods for Psychology (5th ed)**. Duxbury: Pacific Grove; 2002.

22. Lubans DR, Morgan PJ, Dewar D, Collins CE, Plotnikoff RC, Okely AD *et al*: **The Nutrition and Enjoyable Activity for Teen Girls (NEAT girls) randomized controlled trial for adolescent girls from disadvantaged secondary schools: rationale, study protocol, and baseline results**. *BMC Public Health* 2010, **10**:652-65.

23. Lubans DR, Morgan PJ, Aguiar EJ, Callister R: **Randomized controlled trial of the Physical Activity Leaders (PALs) program for adolescent boys from disadvantaged secondary schools**. *Prev Med* 2011, **52**(3):239-46.

24. Lubans DR, Morgan PJ, Okely AD, Dewar D, Collins CE, Batterham M *et al*: **Preventing obesity among adolescent girls: one-year outcomes of the nutrition and enjoyable activity for teen girls (NEAT Girls) cluster randomized controlled trial**. *Arch Pediat Adol Med* 2012, **166**(9):821-27.

25. Commonwealth of Australia: **Australia's physical activity recommendations for 12-18 year olds** Canberra, Department of Health and Ageing; 2004.

26. Deci E, Ryan R: **Instrinsic motivation and self-determination in human behaviour**. New York: Plenum; 1985.

27. Bandura A: **Social foundations of thought and action: A social cognitive theory**. Englewood cliffs, NJ: Prentice-Hall; 1986.

28. Hagger MS, Chatzisarantis NL, Culverhouse T, Biddle SJ: **The Processes by Which Perceived Autonomy Support in Physical Education Promotes Leisure-Time Physical Activity Intentions and Behavior: A Trans-Contextual Model**. *J Educ Psychol* 2003, **95**(4):784-95.

29. Barkoukis V, Hagger MS, Lambropoulos G, Tsorbatzoudis H: **Extending the trans□contextual model in physical education and leisure□time contexts: Examining the role of basic psychological need satisfaction**. *Brit J Educ Psychol* 2010, **80**(4):647-70.

30. Lubans DR, Morgan PJ, Weaver K, Callister R, Dewar DL, Costigan SA *et al*: **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.

31. Bandura A: **Human agency in social cognitive theory**. *Am Psychol* 1989, **44**(9):1175-84.

32. Bandura A: **Self-efficacy: The exercise of control**. In.: New York: Freeman; 1997.

33. U.S Department of Health and Human Services: **Physical activity guidelines for Americans** Washington, DC; 2008,

34. Levine JA, Schleusner SJ, Jensen MD: **Energy expenditure of nonexercise activity**. *Am J Clin Nutr* 2000, **72**(6):1451-54.

35. Levine JA, Vander Weg MW, Hill JO, Klesges RC: **Non-Exercise Activity Thermogenesis: The Crouching Tiger Hidden Dragon of Societal Weight Gain**. *Arterioscl Throm Vas* 2006, **26**(4):729-36.

36. Malik VS, Schulze MB, Hu FB: **Intake of sugar-sweetened beverages and weight gain: a systematic review**. *Am J Clin Nurt* 2006, **84**(2):274-88.

37. Lubans DR, Morgan PJ, McCormack A: **Adolescents and school sport: The relationship between beliefs, social support and physical self-perception**. *Phys Educ Sport Ped* 2011, **16**(3):237-50.

38. Pellegrini AD, Smith PK: **Physical activity play: The nature and function of a neglected aspect of play**. *Child Dev* 1998, **69**(3):577-98.

39. Paquette D, Carbonneau R, Dubeau D, Bigras M, Tremblay RE: **Prevalence of father-child rough-and-tumble play and physical aggression in preschool children**. *Eur J Psychol Educ* 2003, **18**(2):171-89.

40. MacDonald K, Parke RD: **Bridging the gap: Parent-child play interaction and peer interactive competence**. *Child Dev* 1984:1265-77.

41. Australian Bureau of Statistics **Children's participation in cultural and leisure activities.** [http://www.abs.gov.au/ausstats/abs@.nsf/products/4901.0~apr+2012~main+features~internet+and+mobile+phones.] Accessed on 4 February, 2013

42. Weerakkody ND: **Mobile phones and children: an Australian perspective**. *INSITE 2008: Informing Science + Infiormation Technology Education 2008;* Varna, Bulgaria. Informing Science Institute: 459-75.

43. Lenhart A: **Teens, smartphones & texting**. *Pew Internet & American Life Project* 2012.

44. Murray DM: **Design and analysis of group-randomised trials**. New York, NY: Oxford University Press; 1998.

45. Onis Md, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J: **Development of a WHO growth reference for school-aged children and adolescents**. *B World Health Organ* 2007, **85**(9):660-67.

46. Brambilla P, Bedogni G, Heo M, Pietrobelli A: **Waist circumference-to-height ratio predicts adiposity better than body mass index in children and adolescents**. *Int J Obesity* 2013, **37**:943-46.

47. Nielsen B, Dencker M, Ward L, Linden C, Thorsson O, Karlsson M *et al*: **Prediction of fat□free body mass from bioelectrical impedance among 9□to 11□year□old Swedish children**. *Diabetes Obes Metab* 2007, **9**(4):521-39.

48. Lubans DR, Morgan P, Callister R, Plotnikoff RC, Eather N, Riley N *et al*: **Test–retest reliability of a battery of field-based health-related fitness measures for adolescents**. *J Sport Sci* 2011, **29**(7):685-93.

49. Trost SG, McIver KL, Pate RR: **Conducting accelerometer-based activity assessments in field-based research**. *Med Sci Sport Exer* 2005, **37**(11):S531-43.

50. Matthews CE, Hagströmer M, Pober DM, Bowles HR: **Best practices for using physical activity monitors in population-based research**. *Med Sci Sport Exer* 2012, **44**(1 Suppl 1):S68-S76.

51. Evenson KR, Catellier DJ, Gill K, Ondrak KS, McMurray RG: **Calibration of two objective measures of physical activity for children**. *J Sport Sci* 2008, **26**(14):1557-65.

52. Cooper Institute for Aerobics Research: **Fitnessgram: Test administration manual**. Champaign, IL: Human Kinetics; 1999.

53. Ortega FB, Ruiz JR, Castillo MJ, Sjöström M: **Physical fitness in childhood and adolescence: a powerful marker of health**. *Int J Obesity* 2008, **32**(1):1-11.

54. Castro-Piñero J, Artero EG, España-Romero V, Ortega FB, Sjöström M, Suni J *et al*: **Criterion-related validity of field-based fitness tests in youth: a systematic review**. *Brit J Sport Med* 2010, **44**(13):934-43.

55. Ortega FB, Artero EG, Ruiz JR, Vicente-Rodriguez G, Bergman P, Hagströmer M *et al*: **Reliability of health-related physical fitness tests in European adolescents. The HELENA Study**. *Int J Obes* 2008, **32**:S49-S57.

56. Lubans DR, Smith JJ, Harries SK, Barnett L, Faigenbaum AD: **Development, test-retest reliability and construct validity of the Resistance Training Skills Battery**. *J Strength Cond Res* In Press.

57. Hardy LL, Booth ML, Okely AD: **The reliability of the adolescent sedentary activity questionnaire (ASAQ)**. *Prev Med* 2007, **45**(1):71-74.

58. Foehr UG: **Media multitasking among American youth: Prevalence, predictors and pairings**, vol. 7592: Henry J. Kaiser Family Foundation Menlo Park, CA; 2006.

59. Rey-López JP, Ruiz JR, Ortega FB, Verloigne M, Vicente-Rodriguez G, Gracia-Marco L *et al*: **Reliability and validity of a screen time-based sedentary behaviour questionnaire for adolescents: The HELENA study**. *Eur J Public Health* 2012, **22**(3):373-77.

60. Marsh HW: **Physical Self Description Questionnaire: stability and discriminant validity. / Questionnaire d'auto-evaluation physique - validite**. *Res Q Exercise Sport* 1996, **67**(3):249-64.

61. Diener E, Wirtz D, Tov W, Kim-Prieto C, Choi D-w, Oishi S *et al*: **New Well-being Measures: Short Scales to Assess Flourishing and Positive and Negative Feelings**. *Soc Indic Res* 2010, **97**(2):143-56.

62. Gentile D: **Pathological Video-Game Use Among Youth Ages 8 to 18: A National Study**. *Psychol Sci* 2009, **20**(5):594-602.

63. Orpinas P, Frankowski R: **The Aggression Scale: A Self-Report Measure of Aggressive Behavior for Young Adolescents**. *J Early Adolescence* 2001, **21**(1):50-67.

64. Drake C, Nickel C, Burduvali E, Roth T, Jefferson C, Pietro B: **The pediatric daytime sleepiness scale (PDSS): sleep habits and school outcomes in middle-school children**. *Sleep* 2003, **26**(4):455-58.

65. Lubans DR, Foster C, Biddle SJ: **A review of mediators of behavior in interventions to promote physical activity among children and adolescents**. *Prev Med* 2008, **47**(5):463-70.

66. Van Stralen M, Yildirim M, te Velde S, Brug J, Van Mechelen W, Chinapaw M: **What works in school-based energy balance behaviour interventions and what does not: A systematic review of mediating mechanisms**. *Int J Obesity* 2011, **35**(10):1251-65.

67. Goudas M, Biddle S, Fox K: **Perceived locus of causality, goal orientations, and perceived competence in school physical education classes**. *Brit J Educ Psychol* 1994, **64 (Pt 3)**:453-63.

68. Standage M, Duda JL, Ntoumanis N: **A Model of Contextual Motivation in Physical Education: Using Cosntructs From Self-Determination and Achievement Goal Theories to Predict Physical Activity Intentions**. *J Educ Psychol* 2003, **95**(1):97-110.

69. Ng JYY, Lonsdale C, Hodge K: **The Basic Needs Satisfaction in Sport Scale (BNSSS): Instrument development and initial validity evidence**. *Psychol Sport Exerc* 2011, **12**(3):257-64.

70. Lubans DR, Lonsdale C, Plotnikoff RC, Smith JJ, Dally K, Morgan PJ: **Development and evaluation of the Motivation to Limit Screen-time Questionnaire (MLSQ) for adolescents**. *In press*.

71. Ramirez ER, Norman GJ, Rosenberg DE, Kerr J, Saelens BE, Durant N *et al*: **Adolescent Screen Time and Rules to Limit Screen Time in the Home**. *J Adolescent Health* 2011, **48**(4):379-85.

72. Shrout PE: **Measurement reliability and agreement in psychiatry**. *Stat Methods Med Res* 1998, **7**(3):301-17.

73. Dewar D, Lubans DR, Morgan PJ, Plotnikoff RC: **Development and Evaluation of Social Cognitive Measures Related to Adolescent Physical Activity**. *J Phys Act Health* 2013, **10**(4):544-55.

74. Telford A, Salmon J, Jolley D, Crawford D: **Reliability and validity of physical activity questionnaires for children: The Children's Leisure Activities Study Survey (CLASS)**. *Pediatr Exerc Sci* 2004, **16**(1):64-78.

75. Krull JL, MacKinnon DP: **Multilevel mediation modeling in group-based intervention studies**. *Evaluation Rev* 1999, **23**(4):418-44.

76. Sawyer SM, Afifi RA, Bearinger LH, Blakemore S, Dick B, Ezeh AC *et al*: **Adolescence: a foundation for future health**. *Lancet* 2012, **379**(9826):1630-40.

77. Lawlor DA, Chaturvedi N: **Treatment and prevention of obesity—are there critical periods for intervention?** *Int J Epidemiol* 2006, **35**(1):3-9.

78. Singh AS, Mulder C, Twisk JW, Van Mechelen W, Chinapaw MJ: **Tracking of childhood overweight into adulthood: a systematic review of the literature**. *Obes Rev* 2008, **9**(5):474-88.

79. Must A, Strauss RS: **Risks and consequences of childhood and adolescent obesity**. *Int J Obes Relat Metab Disord* 1999, **23**:S2-11.

80. Biddle SJ, Asare M: **Physical activity and mental health in children and adolescents: a review of reviews**. *Brit J Sport Med* 2011, **45**(11):886-95.

81. Morgan P, Saunders K, Lubans D: **Improving physical self‐perception in adolescent boys from disadvantaged schools: psychological outcomes from the Physical Activity Leaders randomized controlled trial**. *Pediatr Obes* 2012, **7**(3):e27-e32.

82. Nihill GFJ, Lubans DR, Plotnikoff RC: **Associations between sedentary behavior and self-esteem in adolescent girls from schools in low-income communities**. *Mental Health Phys Act* 2013, **6**(1):30-35.

83. Kremer P, Elshaug C, Leslie E, Toumbourou JW, Patton GC, Williams J: **Physical activity, leisure-time screen use and depression among children and young adolescents**. *J Sci Med Sport* 2013:In Press.

84. Messias E, Castro J, Saini A, Usman M, Peeples D: **Sadness, suicide, and their association with video game and internet overuse among teens: results from the youth risk behavior survey 2007 and 2009**. *Suicide Life-Threat* 2011, **41**(3):307-15.

85. Robinson TN, Kraemer HC, Matheson DM, Obarzanek E, Wilson DM, Haskell WL *et al*: **Stanford GEMS phase 2 obesity prevention trial for low-income African-American girls: design and sample baseline characteristics**. *Contemp Clin Trials* 2008, **29**(1):56-69.

86. Melnyk BM, Kelly S, Jacobson D, Belyea M, Shaibi G, Small L *et al*: **The COPE healthy lifestyles TEEN randomized controlled trial with culturally diverse high school adolescents: Baseline characteristics and methods**. *Contemp Clin Trials* 2013, **36**(1):41-53.

87. Singh AS, Paw MJCA, Kremers SP, Visscher TL, Brug J, van Mechelen W: **Design of the Dutch Obesity Intervention in Teenagers (NRG-DOiT): systematic development, implementation and evaluation of a school-based intervention aimed at the prevention of excessive weight gain in adolescents**. *BMC Public Health* 2006, **6**(1):304.

88. Singh AS, Paw MJMCA, Brug J, van Mechelen W: **Short-term effects of school-based weight gain prevention among adolescents**. *Arch Pediat Adol Med* 2007, **161**(6):565-71.

89. Singh AS, Paw CA, Marijke J, Brug J, van Mechelen W: **Dutch obesity intervention in teenagers: effectiveness of a school-based program on body composition and behavior**. *Arch Pediat Adol Med* 2009, **163**(4):309-17.

90. Dewar D, Morgan PJ, Plotnikoff RC, Okely AD, Collins CE, Batterham M *et al*: **The Nutrition and Enjoyable Activity for Teen Girls Study: A Cluster Randomized Controlled Trial.** . *Am J Prev Med* 2013, **45**(3):313-17.

91. Safron M, Cislak A, Gaspar T, Luszczynska A: **Effects of school-based interventions targeting obesity-related behaviors and body weight change: a systematic umbrella review**. *Behav Med* 2011, **37**(1):15-25.

92. Sisson SB, Broyles ST, Baker BL, Katzmarzyk PT: **Screen time, physical activity, and overweight in US youth: National Survey of Children's Health 2003**. *J Adolescent Health* 2010, **47**(3):309-11.

93. Must A, Tybor D: **Physical activity and sedentary behavior: a review of longitudinal studies of weight and adiposity in youth**. *Int J Obesity* 2005, **29**:S84-S96.

94. Ginty F, Rennie KL, Mills L, Stear S, Jones S, Prentice A: **Positive, site-specific associations between bone mineral status, fitness, and time spent at high-impact activities in 16- to 18-year-old boys**. *Bone* 2005, **36**(1):101-10.

95. Artero EG, Ruiz JR, Ortega FB, Espana-Romero V, Vicente-Rodriguez G, Molnar D *et al*: **Muscular and cardiorespiratory fitness are independently associated with metabolic risk in adolescents: The HELENA study**. *Pediatr Diab* 2011, **12**(8):704-12.

96. Ortega FB, Silventoinen K, Tynelius P, Rasmussen F: **Muscular strength in male adolescents and premature death: cohort study of one million participants**. *Brit Med J* 2012, **345**.

97. Gray JJ, Ginsberg RL: **Muscle dissatisfaction: an overview of psychological and cultural research and theory**. Washington DC: APA; 2007.

98. Lubans DR, Cliff DP: **Muscular fitness, body composition and physical self-perception in adolescents**. *J Sci Med Sport* 2011, **14**(3):216-21.

Table 1: Intervention components, behavior change techniques and targeted constructs in the ATLAS intervention

Intervention component	Dose	Description	Behavior change strategies	Hypothesized mediators
Teachers				
1) Teacher professional development	2 x 6 hour workshops 1 x fitness instructor session	Teachers attend two professional development workshops during the study period (pre- and mid-program). The workshops provide a rationale for the program, outline the intervention strategies (i.e., program components, behavioral messages) and explain the theory behind the intervention. Each school will receive one visit during their regularly scheduled sport session from a practicing fitness instructor (i.e., personal trainer). The fitness instructor will deliver the session while the teacher observes and completes the session observation checklist.	▪ Provide instruction ▪ General encouragement ▪ Plan social support or social change ▪ Provide information about behavior health link	▪ Motivation in school sport ▪ Perceived autonomy ▪ Perceived competence ▪ Perceived relatedness
Parents				
2) Parent newsletters	4 x newsletters	Parents of study participants will receive four newsletters containing information on the potential consequences of excessive screen-use among youth, strategies for reducing screen-based recreation in the family home, and tips for avoiding conflict when implementing rules. They will also be provided with their child's baseline fitness test results.	▪ Provide feedback on performance ▪ Plan social support or social change ▪ General encouragement ▪ Provide information about behavior health link ▪ Behavior contract	▪ Motivation to limit screen-time ▪ Household screen-time rules
Students				

3)	Researcher-led seminars	3 x 20 mins	Participants will attend three interactive seminars delivered by members of the research team. Seminars will provide key information surrounding the program's components and behavioral messages including current recommendations regarding youth physical activity, screen-time, and resistance training, and will outline the student leadership component of the intervention.	▪ Provide information about behavior health link ▪ Prompt self-monitoring of behaviors ▪ Plan social support or social change ▪ Prompt barrier identification ▪ Prompt specific goal setting	▪ Motivation in school sport ▪ Motivation to limit screen-time
4)	Enhanced school sport sessions	20 x 90 min sessions	Sport sessions will be delivered by teachers at the study schools. Activities will include elastic tubing resistance training, aerobic- and strength-based activities, fitness challenges, and modified ball games. Behavioral messages will be reinforced during the cool-down period.	▪ Information on consequences ▪ Prompt intention formation ▪ Provide instruction ▪ General encouragement ▪ Graded tasks	▪ Motivation in school sport ▪ Perceived autonomy ▪ Perceived competence ▪ Perceived relatedness
5)	Lunch-time physical activity mentoring sessions	6 x 20 min sessions	Students will participate in six lunch-time physical activity mentoring sessions. These self-directed sessions will involve recruiting and instructing grade 7 boys in elastic tubing resistance training.	▪ Model or demonstrate the behavior ▪ Graded tasks ▪ Prompt identification as a role model	▪ Motivation in school sport ▪ Perceived autonomy ▪ Perceived competence ▪ Perceived relatedness
6)	Smartphone application and website	15 weeks	The smartphone application and website will be used for physical activity monitoring, recording of fitness challenge results, tailored motivational messaging, peer assessment of RT skills, and goal setting for physical activity and screen-time.	▪ Provide information about behavior health link ▪ Prompt self-monitoring of behaviors ▪ Prompt specific goal setting ▪ Information on consequences ▪ General encouragement	▪ Motivation in school sport ▪ Perceived competence ▪ Physical activity behavioral strategies ▪ Motivation to limit screen-time
7)	Pedometers	17 weeks	Participants will be provided with pedometers for self-monitoring. Students will be encouraged to set goals to increase their daily step counts and monitor their progress using the pedometer. Pedometer step counts can also be entered into the smartphone application for review.	▪ Prompt self-monitoring of behaviors ▪ Prompt specific goal setting	▪ Physical activity behavioral strategies

Table 2: SAAFE teaching principles

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

Table 3: Hypothesized mediators of physical activity and screen-time

Mediator	Response range (No. of items)	Example item	α[1]
Motivation in school sport		Common stem: *I take part in school sport…*	
Amotivation	1-7(4)	*But I don't really know why*	.78
External regulation	1-7(4)	*Because I'll get in trouble if I don't*	.77
Introjected regulation	1-7(4)	*Because I would feel bad if I didn't*	.75
Identified regulation	1-7(4)	*Because I want to learn sport skills*	.84
Intrinsic regulation	1-7(4)	*Because school sport is exciting*	.85
Psychological needs satisfaction in school sport			
Autonomy (choice)	1-7(4)	*I can decide which activities I want to practice in school sport*	.77
Autonomy (volition)	1-7(3)	*I really have a sense of wanting to take part in school sport*	.73
Autonomy (Internal perceived locus of causality)	1-7(3)	*I am doing what I want to be doing in today's class*	.76
Competence	1-7(4)	*I feel pretty competent in school sport*	.82
Relatedness	1-7(5)	*In school sport I feel listened to*	.84
Motivation to limit screen-time			
Amotivation	0-6(7)	*I don't see why I should try to limit my screen-time*	.84
Controlled motivation	0-6(7)	*I try to limit my screen-time because my parent(s) will get angry with me if I don't*	.65
Autonomous motivation	0-6(7)	*I try to limit my screen-time because I feel it is important to me*	.74
Physical activity behavioral strategies	1-5(6)	Common stem: *In the past three months how often…* *Did you organize to be physically active with a friend or family member*	.74
Screen-time rules	1-3(7)	*Less than 2 hours of recreational screen-time per day*	NR

***Note*. NR = not relevant**
[1]Chronbach's alpha's derived from the ATLAS study sample

Table 4: Baseline characteristics of study sample

Characteristics[1]	Control (n = 181)		ATLAS (n = 180)		Total (N = 361)	
	Mean	SD	Mean	SD	Mean	SD
Age (years)	12.8	0.5	12.7	0.5	12.7	0.5
Country of birth, n (%)[2]	163	93.7%	171	96.1%	334	94.9%
Language spoken at home, n (%)[3]	164	94.8%	172	96.6%	336	95.7%
Cultural background						
Australian, n (%)	127	73.8%	143	80.3%	270	77.1%
Asian, n (%)	3	1.7%	4	2.2%	7	2.0%
African, n (%)	6	3.5%	1	0.6%	7	2.0%
European, n (%)	30	17.4%	22	12.4%	52	14.9%
Middle Eastern, n (%)	2	1.2%	0	0%	2	0.6%
Other, n (%)	4	2.3%	8	4.5%	12	3.4%
ATSI descent, n (%)[4]	18	10.5%	29	16.3%	47	13.5
Socio-economic status[5]						
1-2, n (%)	55	30.9%	49	27.3%	104	29.1%
3-4, n (%)	81	45.5%	119	66.1%	200	55.9%
5-6, n (%)	27	15.2%	4	2.2%	31	8.6%
7-8, n (%)	8	4.5%	8	4.4%	16	4.5%
9-10, n (%)	7	3.9%	0	0%	7	2.0%
Weight (kg)	53.2	13.5	53.9	15.0	53.5	14.2
Height (cm)	160.2	8.4	160.9	9.0	160.5	8.7
BMI (kg/m^2)	20.5	4.2	20.6	4.3	20.5	4.2
Weight status (BMI *z*-score)						
Underweight, n (%)	5	2.8%	2	1.1%	7	1.9%
Healthy weight, n (%)	115	63.5%	110	61.1%	225	62.3%
Overweight, n (%)	38	21.0%	39	21.7%	77	21.3%
Obese, n (%)	23	12.7%	29	16.1%	52	14.4%
BIA (body fat %)	22.4	8.3	20.0	8.5	21.2	8.5
Waist circumference (cm)	76.6	12.4	76.2	12.4	76.4	12.4
WCHt	0.48	0.07	0.47	0.07	0.48	0.07
Push-up test (reps)	7.2	6.0	9.6	6.6	8	6
7-stage sit up test (level)	3.3	1.6	3.8	1.9	3.5	1.8
Hand grip strength (kg)	19.6	4.9	21.5	5.4	20.5	5.3
RTSQ	38.3	6.0	40.0	5.1	39.1	5.6
SSR (mins/day)	136	100	118	80	127	91
Pathological video gaming, n (%)[6]	22	12.6%	16	9.0%	38	10.8%
MVPA (mins/day)	61	22	66	21	63	22
SSB intake (>2 glasses/day), n (%)	162	92.6%	169	94.9%	331	93.8%

Note. **SD = standard deviation; ATSI = Aboriginal or Torres Strait Islander; BMI = body mass index; BIA = bioelectrical impedance analysis; WCHt = waist circumference to height ratio; RTSQ = resistance training skills quotient; SSR = small screen recreation; MVPA = moderate to vigorous physical activity; SSB = sugar sweetened beverages.**

[1]13, 9, 10, 11, 12, 3, 3, 5, 34, 4, 8, and 8 participants had missing data for age, country of birth, language spoken at home, cultural background, ATSI descent, socio-economic status, BIA, push-ups, RTSQ, SSR, pathological gaming, and SSB intake, respectively.

[2]Participants born in Australia.

[3]Participants who speak English at home.

[4]Participants that are of ATSI descent.

[5]Based on SEIFA decile of residential postcode.

[6]Participants that qualify as pathological video gamers

Figures

Figure 1: Study design and flow

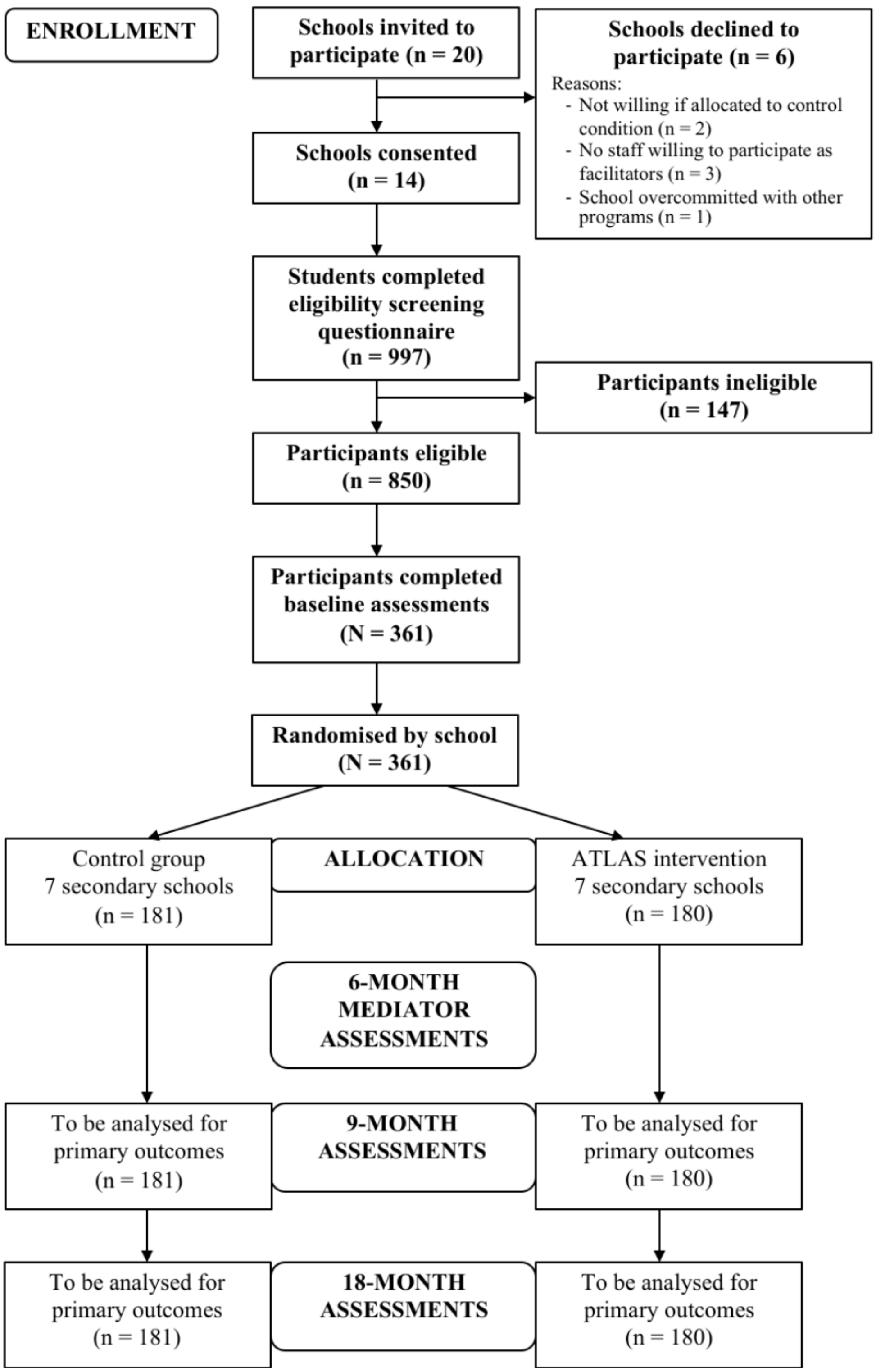

Figure 2: ATLAS intervention components, potential mediators and outcomes