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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

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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.

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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

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1. Introduction

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 [9]. Of the various sedentary behaviors, screen-based recreation (screen-time) contributes the most to leisure-time sedentary behavior among youth [10]. International guidelines recommend limiting screen-time to less than 2 h per day, but 83% of Australian [11], 71% of English, 64% of Canadian and 54% of US adolescent boys exceed these guidelines [12]. Reducing screen-time has been identified as an important strategy for preventing the development of obesity and improving the psychosocial health of young people [13,14].

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 [15]. However, school-based obesity prevention interventions targeting adolescents have had mixed success [16]. 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 [17,18] such as youth from low-income communities. Furthermore, as both the determinants and the prevalence of obesity are moderated by gender [19], gender-specific programs may be more suitable and efficacious [20–22]. 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 and study description for the 'Active Teen Leaders Avoiding Screen-time' (ATLAS) program, an innovative obesity prevention intervention for adolescent boys living in low-income communities.

2. Methods/design

2.1. Study design

The ATLAS intervention will be evaluated using a cluster randomized controlled trial (RCT) (Fig. 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 [23]. 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.

2.2. 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 [24,25]. Based on the existing literature, a difference of 0.4 kg m^{-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 a similar school-based obesity prevention trial) [26]. Baseline post-test correlations ($r = .97$) and standard deviation (SD = 1.1 kg m^{-2}) estimates were taken from our pilot study [20]. 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 kg m^{-2}. Similarly, the proposed sample size would be adequately powered to detect a between-group difference of 1.5 cm 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 [20,21], we aimed to recruit 350 participants from 14 schools (i.e., 25 from each school).

2.3. 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

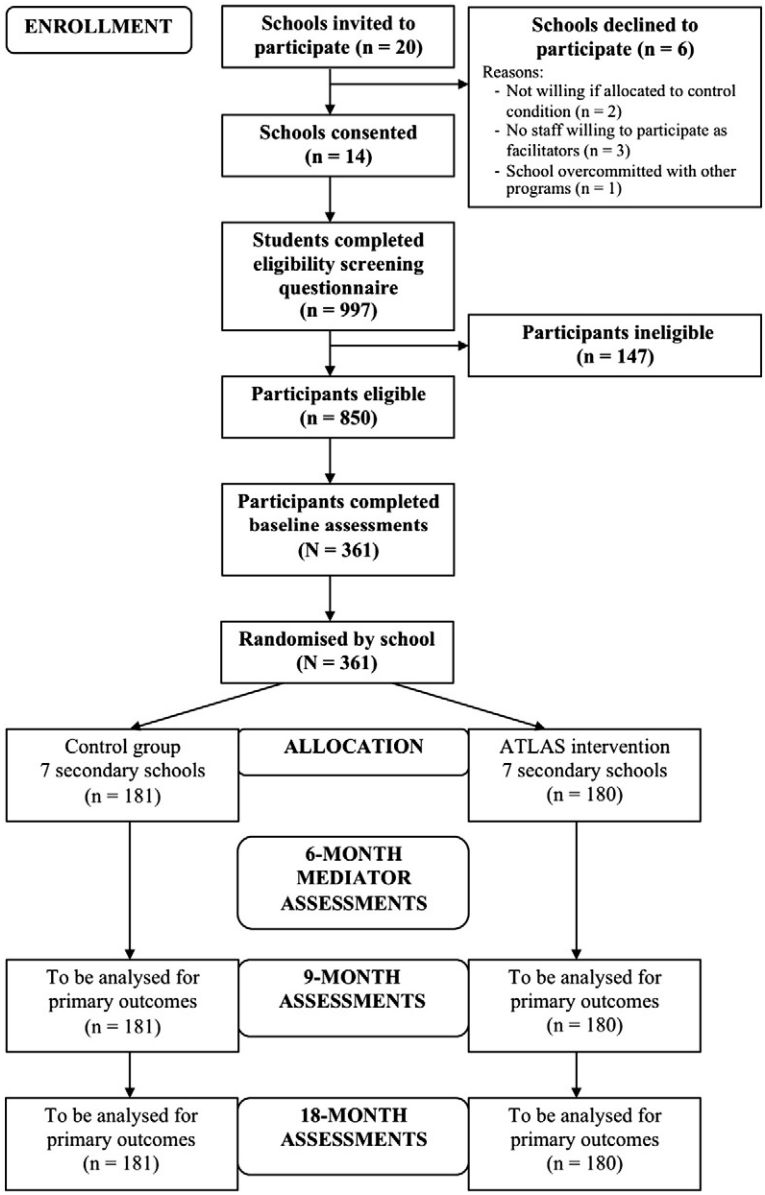

Fig. 1. Study design and flow.

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.

2.4. 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 (i.e., ≥ 2 h of screen-based recreation per day and/or <7 days per week of moderate-to-vigorous intensity physical activity [MVPA] of at least 60 min duration per day) [27]. 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]. All eligible students received information and consent forms. The recruitment target was 25 students per school; however,

up to 30 students from each school could be accepted. The first 30 students from each school to return their completed consent form were included in the study.

2.5. 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.

2.6. Intervention

ATLAS is an 8-month multi-component physical activity and sedentary behavior intervention for adolescent boys 'at risk' of obesity (Fig. 2). The intervention is based on the Physical Activity Leaders (PALs) RCT [20,28], 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.

2.6.1. Theoretical basis of ATLAS

The ATLAS intervention was developed with reference to self-determination theory (SDT) [29] and social cognitive theory (SCT) [30]. Specifically, the intervention is guided by the trans-contextual model of motivation [31], 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 [32]. 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

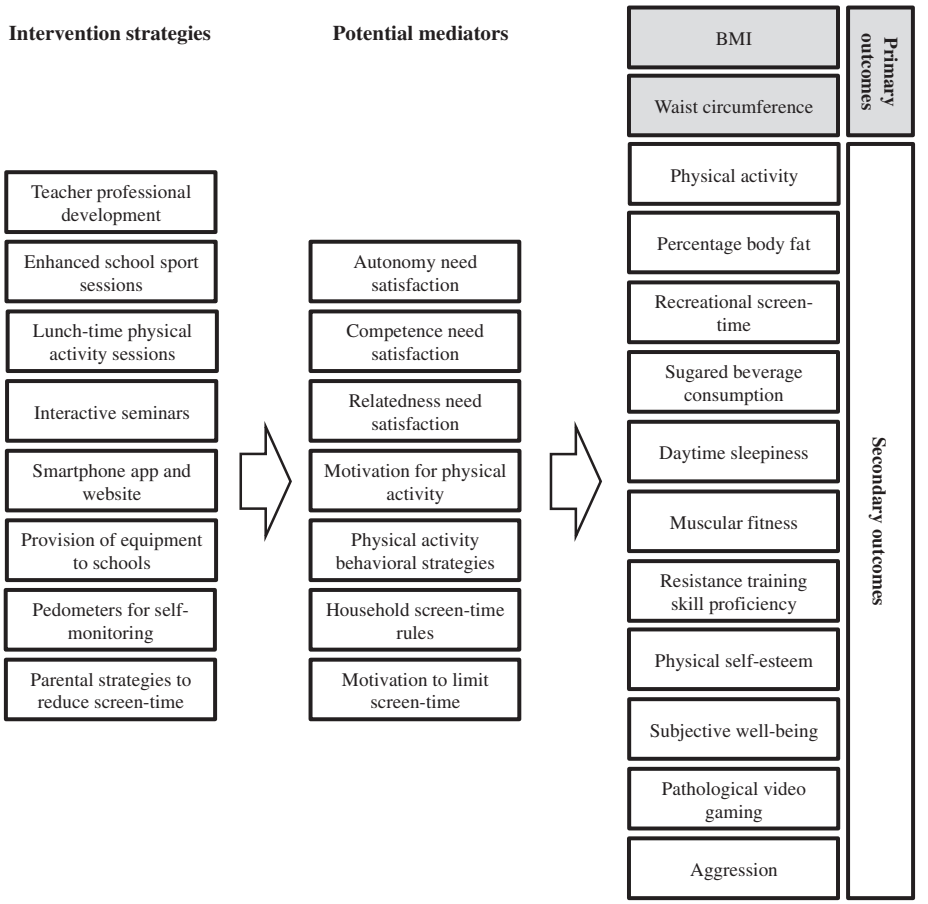

Fig. 2. ATLAS intervention components, potential mediators and outcomes.

Table 1
Intervention components, behavior change strategies and targeted constructs in the ATLAS intervention.

Intervention component	Dose	Description	Behavior change strategies	Hypothesized mediators
Teachers				
1) Teacher professional development	2 × 6 hour workshops 1 × 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 × 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 × 20 min	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 × 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

needs are operationalized through the SAAFE (Supportive, Active, Autonomous, Fair and Enjoyable) teaching principles [33] (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 [34]. 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 [35]. The 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.

2.6.2. 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 h 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 five years of service are able to claim 12 h 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.

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.

2.6.3. Intervention components and delivery

2.6.3.1. 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 [36]. In addition to a focus on developing muscular fitness, the intervention also aims to increase 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 [37]. 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 [38]. 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 (SSBs). Regular consumption of SSBs, 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 [39]. 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 [20]. 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.

2.6.3.2. Enhanced school sport sessions. School sport, while available in a variety of formats [40], 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 [40]. 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 [41]. 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) [42]. 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 [42,43].

2.6.3.3. 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 min 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.

2.6.3.4. 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 [44] and 90% of adolescents over the age of 15 [45] own mobile devices (i.e., smartphones or tablets). Smartphone ownership among youth has accelerated and doesn't appear to be moderated by SES [46]. 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?*).

2.6.3.5. 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.

2.6.4. Control group

To prevent compensatory rivalry and resentful demoralization [47], 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.

2.7. 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.

2.7.1. Primary outcomes

2.7.1.1. Height and weight. Weight was measured to the nearest 0.1 kg 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 [48].

2.7.1.2. Waist circumference. Waist circumference was measured to the nearest 0.1 cm against the skin using a non-extensible steel tape (KDSF10-02, KDS corporation, Osaka, Japan) in line with the umbilicus.

2.7.2. Secondary outcomes

2.7.2.1. 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 [49] 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]) [50].

2.7.2.2. 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 [51] 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 8 h (i.e., 480 min) of total wear time recorded. Non-wear time was defined as 30 min of consecutive zeros. A recent review identified eight and 10 h of wear time as the most commonly used protocols in adolescent studies [52]. The mean activity counts per minute (CPM) were calculated, while the thresholds for activity counts proposed by Evenson et al. [53] 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.

2.7.2.3. Muscular fitness. The 90-degree push-up test was used as a measure of upper body muscular endurance [54]. 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 bpm, allowing one push-up every 3 s. 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]) [50].

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. [55], 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 3 s 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 [56]. In addition,

grip strength testing has demonstrated acceptable test–retest reliability among adolescents [57].

2.7.2.4. Resistance training skill competency. Resistance training skill competency was assessed using video analysis of the Resistance Training Skills Battery (RTSB) [58]. 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 s between sets. The assessor did not provide verbal encouragement or skill specific feedback during the performance of the skill. The RTSB has demonstrated satisfactory concurrent validity ($r = .52$, $p = <.001$) and test–retest reliability (ICC [95%CI] = .88 [.80 to .93]) among a sample of adolescents [58].

2.7.3. Student questionnaire

2.7.3.1. Recreational screen-time. A modified version of the Adolescent Sedentary Activity Questionnaire (ASAQ) [59] 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) [60,61]. 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 [60,61]. Students were also asked to list their three favorite computer/video games.

2.7.3.2. 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 (SSBs). 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*).

2.7.3.3. Physical self-concept. Items from the perceived strength subscale of the Physical Self-Description Questionnaire (PSDQ) [62] 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 [62] and the perceived strength subscale has satisfactory reliability in the current sample (Cronbach's $\alpha = .69$) [62].

2.7.3.4. Subjective well-being. Diener and colleagues' psychological flourishing scale [63] 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 [63], and acceptable reliability in the current sample (Cronbach's $\alpha = .88$).

2.7.3.5. Pathological video gaming. Gentile's pathological video gaming scale [64] 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 [64] and has shown acceptable reliability in the current sample (Cronbach's $\alpha = .76$).

2.7.3.6. Aggression. Aggressive behavior was assessed using an aggression scale designed for young adolescents [65]. 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 [65] and has shown acceptable reliability in the current sample (Cronbach's $\alpha = 90$).

2.7.3.7. Daytime sleepiness. Three items from the Pediatric Daytime Sleepiness Scale [66] 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 (Cronbach's $\alpha = .63$), this is likely the result of only three items being used.

2.8. 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 [67,68]. 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.

2.8.1. Motivation in school sport

Motivational regulations for school sport outlined in SDT were assessed with an adapted scale used by Goudas et al. [69]. 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*).

2.8.2. Psychological needs satisfaction

19 items from existing validated scales [70,71] 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*).

2.8.3. Motivation to limit screen-time

The Motivation to Limit Screen-time Questionnaire (MLSQ) [72] 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) [29]. 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 × 2] +[Controlled × −1] + [Amotivation × −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 [72].

2.8.4. Screen-time rules

Screen-time rules from a survey developed by Ramirez et al. [73] 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) [74] among adolescents and the presence of these rules has been shown to be significantly inversely associated with screen-time [73].

2.8.5. Physical activity behavioral strategies

Students responded to six items developed by Dewar et al. [75] 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]) [75].

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

Mediator	Response range (no. of items)	Example item	α[a]
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 h of recreational screen-time per day*	NR

Note. NR = not relevant.
[a] Cronbach's alpha's derived from the ATLAS study sample.

2.9. 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 × 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. All observations are conducted by an assessor with a background in physical education, after familiarization with the observation checklist. Teachers used the same checklist to observe the researcher-led session conducted at the beginning of the intervention.

2.10. 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 models will be used to assess the impact of treatment (ATLAS or control), time (treated as categorical with levels baseline and 9-months) and the group-by-time interaction, these three terms forming the base model. The models will be specified to adjust for the clustered nature of the data and will include all randomized participants in the analysis. Mixed models are robust to the biases of missing data and provide an appropriate balance of Type 1 and Type 2 errors [76]. Mixed model analyses are consistent with the intention-to-treat principle, assuming the data are missing at random [77]. Differences between completers and those who drop out of the study will be examined using Chi-square and independent samples t-tests. Multiple imputation will be considered as a sensitivity analysis if the dropout rate is substantial. Sub-group analyses will be conducted with participants classified as overweight or obese at baseline for all body composition outcomes. Additional moderators of intervention effects (e.g., ethnicity and SES) will be explored using linear mixed models with interaction terms. Hypothesized mediators of physical activity and sedentary behavior change will be examined using multilevel linear analysis and a product-of-coefficients test that is appropriate for cluster randomized controlled trials [78].

3. Results

The study design and flow can be found in Fig. 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%.

4. Discussion

Adolescence is a life phase crucial to future health and has been described as a critical period for the prevention of obesity [79,80]. Supporting this contention is strong evidence that obesity tracks into adulthood [81]. While the physiological benefits of maintaining a healthy weight across the lifespan are numerous [82], 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 [83,84] and, while more prospective and experimental data are required, evidence suggests that excessive screen-time is associated with lower self-esteem [85] and may even increase the risk of depression [86,87]. 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 [26]. While a number of studies have targeted minority youth [88,89] and youth from low-income communities [26,90], to the authors' knowledge, apart from the PALs pilot study [20] 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 [90] resulted in short-term improvements in body composition for boys and girls [91], but after 20 months the improvements observed among boys were no longer significant [92]. By contrast, the NEAT Girls program found a significant between-group difference of 2% body fat at 24 months [22], despite non-significant findings immediately post-program at 12 months [21]. Further testing through interventions using rigorous methodologies is required to determine the effectiveness of targeted and tailored interventions among youth.

Considering the limited impact of previous obesity prevention interventions [93], 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 [20,26] 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 are related to weight status in youth [94,95]. Furthermore, this method is replicable and relatively easy to administer.

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 [55]. Evidence suggests that, among youth, muscular fitness levels (i.e., strength, power, and muscular endurance) are related to indices of bone health [96], cardiovascular disease risk factors [97], and may also be protective against future mental health problems and risk of suicide [98]. 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 development through the use of resistance training. Perceived strength and muscularity have been identified as important contributors to self-esteem among young males [99,100]. Targeting the muscular fitness domain therefore represents 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.

There are some limitations that need to be addressed. Firstly, the lack of an economic evaluation precludes us from determining the cost-effectiveness of the intervention. Secondly, it is important to note that due to the targeted nature of the intervention, the findings may not be generalizable to different groups (e.g., females and those within other socio-economic strata) or the broader population as a whole.

5. Conclusion

This paper has outlined the rationale and study protocol for 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 SSBs. In addition to providing evidence on the modifiability of key weight-related behaviors among adolescent boys, the ATLAS intervention will improve our understanding 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.

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.

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