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David R. Lubans, Jordan J. Smith, Philip J. Morgan, Mark R. Beauchamp, Andrew Miller, Chris Lonsdale, Philip Parker, Kerry Dally "Mediators of Psychological Well-being in Adolescent Boys". Originally published in Journal of Adolescent Health, Volume 58, Issue 2, Pages 230-236, ISSN 1054-139X (2016)

Available from: <u>http://dx.doi.org/10.1016/j.jadohealth.2015.10.010</u>

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Accessed from: http://hdl.handle.net/1959.13/1326306

Mediators of Psychological Well-being in Adolescent Boys

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Trial registration: Australian New Zealand Clinical Trials Registry No: ACTRN12612000978864

Acknowledgements

This study was funded by an Australian Research Council Discovery Project grant (DP120100611). We would like to thank Tara Finn, Sarah Kennedy, Emma Pollock, and Mark Babic for their assistance with data collection. In addition we would like to thank Geoff Skinner and for his assistance with the ATLAS smartphone application. Finally, we would like to thank the schools, teachers, parents, and study participants for their involvement.

Abstract

Objectives: The aim of this study was to explore the effect of the 'Active Teen Leaders Avoiding Screen-time' (ATLAS) intervention on psychological well-being in adolescent boys and to examine the potential mediating mechanisms that might explain this effect. *Methods:* ATLAS was evaluated using a cluster randomized controlled trial in 14 secondary schools located in low-income communities (N = 361 adolescent boys, mean age = 12.7 ± 0.5 years). The 20-week intervention was guided by self-determination theory and involved: teacher professional development for teachers, provision of fitness equipment to schools, enhanced school sport sessions, researcher-led seminars, a smartphone application, and parental strategies for reducing screen-time. Assessments were conducted at baseline and immediately post-intervention (8-months). Psychological well-being was measured using the Flourishing scale. Behavioral regulations and basic psychological needs in school sport, muscular fitness, resistance training skill competency, and recreational screen-time were examined as potential mediating mechanisms of the intervention effect.

Results: The intervention effect on well-being was small but statistically significant. Within a multiple mediator model, changes in autonomy needs satisfaction, recreational screen-time and muscular fitness significantly mediated the effect of the intervention on psychological well-being.

Conclusions: In addition to the physical health benefits, targeted physical activity programs for adolescent boys may have utility for mental health promotion through the mechanisms of increasing autonomy support and muscular fitness and reducing screen-time.

Trial registration: Australian New Zealand Clinical Trials Registry No: ACTRN12612000978864

Key words: Obesity prevention; eHealth; Intervention; Physical activity; Behavior change

Implications and conclusions

This study suggests that satisfying adolescent boys' psychological needs for autonomy, improving their muscular fitness and reducing their recreational screen-time may positively influence well-being. While the primary aim of the ATLAS intervention was obesity prevention, the program had small, but beneficial 'spillover effects' on psychological wellbeing.

Introduction

Mental health is not merely the absence of a mental health disorder, but a state of psychological well-being in which an individual realizes his or her own abilities, is resilient to the stresses of life and is able to make a positive contribution to his or her community [1]. A 'eudemonic' view of well-being posits that psychological flourishing is fostered through ongoing efforts to achieve one's 'true potential' and live a meaningful and purposeful life [2]. Eudemonic well-being is comprised of various aspects of feeling and functioning, including competence, emotional stability, engagement, meaning, optimism, positive emotion, positive relationships, resilience, self-esteem, and vitality [3]. According to the tenets of self-determination theory (SDT), well-being is achieved by satisfying basic psychological needs for social connectedness, autonomy and environmental mastery (or competence) [4].

High levels of well-being are associated with a range of positive outcomes, including effective learning, satisfying interpersonal relationships, and greater life expectancy [5, 6]. More recently, evidence has emerged suggesting that high levels of recreational screen-time (i.e., TV, computer and electronic gaming) and low levels of physical activity and health-related fitness (most notably cardio-respiratory and muscular fitness) are associated with poor mental health and well-being in young people [7-10]. Improving muscular fitness may be of particular importance among Western males, among whom ideals of masculinity and strength are highly valued [11].

Excessive screen-time, physical inactivity and poor fitness may have a detrimental impact on adolescents' psychological well-being, but there is a lack of causal evidence, as the majority of studies have been cross-sectional [7, 12, 13]. Carefully designed experimental studies combined with statistical mediation tests are needed to determine the influence of changes in behaviors and fitness on well-being in young people [14]. Such information may

assist in the design of school- and community-based interventions for those 'at risk' of poor health. Adolescent boys from low-income communities are one such group. While adolescent boys are typically more active than girls, approximately 78% of boys fail to accrue the amount of physical activity considered necessary to promote good health [15]. Furthermore, adolescent boys are more likely to engage in high levels of recreational screen-time [16]. Such findings highlight the importance of developing and evaluating programs and policies for adolescent boys who are 'at risk' of poor physical and psychological health.

The 'Active Teen Leaders Avoiding Screen-time' (ATLAS) obesity prevention program was a multi-component school-based intervention based on SDT that targeted adolescent boys with low levels of physical activity and/or high levels of recreational screentime [17]. The effects of the intervention on body composition and health behaviors have been reported previously [18]. In summary, there were significant group-by-time effects for recreational screen-time, muscular fitness and resistance training skill competency [18], but not for physical activity or body composition. The overall purpose of this paper is to explore the impact of the ATLAS program on psychological well-being and to determine the mediating mechanisms that might explain this effect. In the context of the ATLAS intervention, muscular fitness and resistance training skill competency were regarded as objective measures of competence. In light of the significant intervention effects mentioned previously and allied with the tents of SDT, our hypotheses were as follows: compared with the control condition, adolescents in the intervention condition would report higher levels of psychological well-being. Furthermore, we hypothesized that *improvements* in autonomous motivation, basic psychological needs, muscular fitness and resistance training skill competency, as well as *reductions* in screen-time would partially mediate the effect of the ATLAS intervention on psychological well-being among low-income adolescent boys.

Methods

Study design, participants and setting

Participants for the present study were 361 adolescent boys (mean age, 12.7 ± 0.5 years) taking part in the ATLAS program. A detailed description of the study methodology and primary outcome findings can be found elsewhere [17, 18]. In summary, ATLAS was evaluated using a cluster randomized controlled trial (RCT) in 14 secondary schools located in low-income areas of New South Wales (NSW), Australia. Eligible schools were identified using the Socio-Economic Indexes for Areas (SEIFA) Index of Relative Socio-economic Disadvantage. Secondary schools located in the Newcastle, Hunter, and Central Coast areas of NSW with a SEIFA index of ≤ 5 (lowest 50%) were eligible to participate in the study. Eligible study participants were adolescent males in grade seven (first year of secondary school) who reported failing to meet international guidelines regarding physical activity or recreational screen-time [19]. Study participants were randomized at the school level to either the ATLAS intervention (n = 181) or a wait-list control group (n = 180). Randomization was performed by an independent researcher using a computer-based random number producing algorithm. Baseline assessments were conducted in November-December, 2012 and 8-month follow-up assessments were completed in July-September, 2013. Ethics approval for this study was obtained from the Human Research Ethics Committees of the University of Newcastle and the NSW Department of Education and Communities. School principals, teachers, parents and students provided informed written consent.

Sample size calculation

The original study power calculation was conducted to determine the sample size needed to detect changes in the primary outcomes (i.e., BMI and waist circumference) at the primary end-point of 8-months. Power calculations were based on 80% power with alpha levels set at p < 0.05, baseline posttest correlations (r = 0.97) and standard deviation (SD = 1.1 kgm⁻²) estimates from our pilot study [20] and assumed a school clustering effect of 0.03. 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. The current study was sufficiently powered to detect small-to-medium mediation effects using the PRODCLIN program (distribution of the PRODuct Confidence Limits for INdirect effects) [21].

Intervention

ATLAS was a school-based obesity prevention intervention targeting the health behaviors (i.e., physical activity, screen-time and sugar-sweetened beverage) of low-income adolescent boys considered 'at-risk' of obesity and was based on the Physical Activity Leaders (PALs) pilot trial [20, 22]. ATLAS was delivered over 20-weeks and consisted 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. ATLAS was designed with reference to SDT [23] and the intervention aimed to enhance competence, relatedness, and autonomy needs satisfaction during school sport, in order to increase boys' self-determined motivation for physical activity. In addition, the intervention aimed to increase boys' competence for resistance training through the development of foundation resistance training movement skills. The face-to-face component of the intervention was delivered by participating teachers at the study schools following a pre-program professional development workshop delivered by members of the research team. The workshop was designed to familiarize teachers with the intervention components, sport session structure, and key theoretical constructs; which were operationalized through the SAAFE (Supportive, Active, Autonomous, Fair, and Enjoyable) teaching principles. Further detail regarding the intervention components and theoretical basis of the program can be found elsewhere [17].

Outcome measures

Assessors were blinded to group allocation at baseline, but not at posttest. Demographic information was collected using a questionnaire and participant socio-economic status (SES) was defined as the SEIFA decile corresponding to the participants' residential postcode. The primary outcome in this investigation was psychological well-being, measured using Diener and colleagues' 8-item psychological flourishing scale [24]. Composite scores of flourishing represent a summary measure of a person's self-perceived success in areas such as engagement, relationships, self-esteem, meaning, purpose, and optimism. Example item- "*I am competent and capable in the activities that are important to me*". This scale has satisfactory construct validity [24], and acceptable reliability in the current sample (Cronbach's $\alpha = .88$).

Recreational screen-time was measured using a modified version of the Adolescent Sedentary Activity Questionnaire (ASAQ)[25]. The valid and reliable ASAQ requires respondents to report the total time spent using screens (of any kind), for the purpose of entertainment, on each day of the week [25].

Upper body muscular endurance was measured using the 90-degree push-up test. This test has acceptable test–retest reliability in adolescents (ICC [95%CI] = .90 [.80 to .95]) [26]. *Resistance training movement skill competency* was assessed using video analysis of the Resistance Training Skills Battery (RTSB) [27], a process-based instrument designed to assess proficiency in six foundational resistance training movements (i.e., squat, lunge, push-up, overhead press, front-support with chest touches, and suspended row). The RTSB was found to have acceptable test-retest reliability (ICC [95%CI] = .88 [.80 to .93]) and concurrent validity (r = .52, p < .001) in a sample of adolescents.

Motivational regulations for school sport were assessed using an adapted version of the scale developed by Goudas et al. [28]. The original items designed for use in the physical education context, 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*). Subscales and Cronbach alphas were as follows: amotivation (α = .78), external regulation (α = .77), introjected regulation (α = .75), identified regulation (α = .84) and intrinsic regulation (α = .85).

Psychological needs satisfaction in school sport was assessed using 19 items from existing validated scales [29] for autonomy [i.e., choice ($\alpha = .77$), volition ($\alpha = .78$), and internal perceived locus of causality ($\alpha = .76$)], competence ($\alpha = .82$) and relatedness ($\alpha = .84$) 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).

Analysis

Posttest assessments were completed for 152 (84.4%) control group and 137 (75.7%) intervention group participants, representing an overall retention rate of 80.1% from baseline. Differences between groups at baseline and differences between those who completed the study and those who dropped out were analyzed using SPSS (Version 19, SPSS Inc. Chicago, IL). As data were missing at random (Little's MCAR test, chi square = 543.2, p = 0.371),

estimation maximization was used to impute missing data following the intention to treat principle. A sensitivity analysis was conducted using complete cases only. As findings were similar, results from the intention to treat are only reported.

All analyses were conducted using multi-level linear regression analysis in MPlus (Version 7.2, Muthen and Muthen). Two levels were defined in our multi-level analyses: 1) student and 2) school. All analyses were adjusted for participants' residential SES and respective baseline values, which were included as covariates. Before undertaking the mediation analysis, the effect of the intervention (C coefficient) on well-being was determined by regressing posttest values onto treatment condition (i.e., control or intervention).

The product-of-coefficient mediation analysis (Figure 1) consisted of three stages: Stage 1, the effect of the intervention on potential mediators was tested by regressing the potential mediators onto the treatment condition (A coefficient). Stage 2, the relationship between changes in mediators and changes in well-being was explored by regressing wellbeing onto treatment condition and potential mediators (B coefficient). In stage 3, the significance of the product-of-coefficients was tested (AB) by computing the confidence intervals for the mediated effect on the basis of the distribution-of-product method using the R-mediation package developed by Tofighi and MacKinnon [30]. For a variable to satisfy the criteria for mediation, the 95% confidence intervals for the product-of-coefficients (AB) must not include zero. To determine the independent contribution of individual mediators, a multiple mediator model was run that included all significant mediators from Stage 1.

Results

Demographic characteristics of participants are provided in Table 1. Results from the single and multiple mediator models can be found in Tables 3 and 4, respectively. Participants who did not complete follow-up assessments were more active on weekdays (p = .03), but there

were no significant differences for health-related fitness (including body composition outcomes), screen-time, behavioral regulations and basic needs satisfaction in school sport. *Effect of the intervention on well-being*

After adjusting for school and baseline values, the intervention effect on well-being was small, but statistically significant (C = 0.10, SE = 0.05, p = 0.023).

Effect of the intervention on potential mediators

After adjusting for school and baseline values, the intervention effects on autonomy-choice (A = 0.15, SE = 0.06, p = 0.016), screen-time (A = -0.21, SE = 0.06, p < 0.001), muscular fitness (A = 0.12, SE = 0.05, p = 0.011), and RT skill competency (A = 0.48, SE = 0.04, p < 0.001) were statistically significant.

Effect of the mediators on well-being

In the single mediator models, changes in well-being were positively associated with changes in basic psychological needs and the different types of behavioural regulations. Only amotivation (negative association) and external regulation (not significant) were not positively associated with well-being. The relationships between changes in well-being and changes in muscular fitness (B = 0.18, SE = 0.10, p = 0.064) and RT skill competency (B = 0.11, SE = 0.06, p = 0.082) were not statistically significant.

Significance of the mediated effect in the single mediator models

In the single mediator models, only autonomy-choice (AB = 0.026, 95% CI = 0.004 to 0.055) and screen-time (AB = 0.044, 95% CI = 0.006 to 0.096) satisfied the criteria for mediation. *Significance of the mediated effect in the multiple mediator model*

In the multiple mediator model that included autonomy-choice, screen-time, muscular fitness, RT skill competency, changes in all mediators except for RT skill competency were significantly associated with changes in well-being. Autonomy-choice (AB = 0.024, 95% CI = 0.004 to 0.052), screen-time (AB = 0.038, 95% CI = 0.007 to 0.080) and muscular fitness (AB = 0.026, 95% CI = 0.003 to 0.061) satisfied the criteria for mediation.

Discussion

The aim of this study was to explore the effect of the ATLAS intervention on adolescent boys' psychological well-being and examine the potential mediating effects of motivation, basic psychological needs, muscular fitness, resistance training skill competency, and screentime. The effect of the ATLAS intervention on psychological well-being was small, but statistically significant. The results also demonstrated that the effect on boys' psychological well-being was mediated by changes in increasing autonomy support, muscular fitness and screen-time that were derived through the ATLAS intervention. When taken together, the results suggest that a theory-driven, evidence based intervention can have a small, but beneficial effect on well-being in adolescent boys.

There is emerging evidence that behavioral interventions may have additional effects (i.e., ripple effects) on physical, psychological and social outcomes beyond the intended primary outcome [31]. However, few obesity prevention interventions have investigated the effects of their programs on well-being in young people [32]. Van Wijnen and colleagues [32] conducted a systematic review of school-based obesity prevention programs and found only seven studies that examined their impact on a wide variety of 'well-being' measures (e.g., self-concept, aggression, media internalization). Of the seven studies, only two reported positive intervention effects for well-being outcomes. More recently, physical activity and obesity prevention interventions have reported positive effects for improved physical self-concept [22] and increased health-related quality of life [33]. Consistent with the tenets of SDT, the current study assessed a 'eudemonic' view of well-being using Diener and colleagues' [24] flourishing scale.

Of particular relevance to the current study, Deci and Ryan [23] posit that by targeting individuals' basic psychological needs for competence, relatedness and autonomy, people will be more likely to feel that they are pursuing a meaningful and purposeful life (i.e., experience greater psychological well-being). Changes in basic psychological needs and the different types of behavioural regulations were positively associated with changes in well-being over the 8-month study period. Only amotivation (negative association) and external regulation were not positively associated with well-being. Yet, autonomy-choice was the only SDT construct (e.g., example item- "*In my school sport, I get opportunities to make choices*") that mediated the effect of the intervention on well-being. Teachers in the intervention group were encouraged to provide students with three opportunities for choice within each session (e.g., music playing, difficulty of fitness challenge, training partner). However, the intervention impact on choice was minimal. Alternatively, boys in the control group reported significant reductions in autonomy support scores at posttest, suggesting that teachers in the control group were thwarting boys' needs for autonomy and choice.

Changes in screen-time mediated the effect of the intervention on well-being in both the single and multiple mediator models. These findings are consistent with previous work that has found low levels of psychological well-being among adolescents are associated with high levels of screen-time. A study of Dutch secondary students, heavy internet and videogame usage was associated with more psychological problems, greater unhappiness and less physical activity [34]. In a study of Australian adolescents, the significant inverse relationship between screen-time and well-being was independent of physical activity [8]. Our research substantively builds upon these findings by examining the effects of screen-time in relation to adolescent well-being using an experimental design.

In the context of the ATLAS intervention, muscular fitness and resistance training skill competency were considered objective measures of actual 'competence'. While there were significant effects for both outcomes, only fitness emerged as a significant mediator of the intervention effect on well-being in the multiple mediator model. Muscular fitness has important health benefits for adolescents, including reductions in adiposity and metabolic risk, improved bone health and elevated levels of self-esteem [35]. Further, muscular fitness is an essential component of motor skill performance (e.g. jumping, running and throwing), and developing competence to perform resistance training during the growing years may support and encourage participation in sport and physical activity as an ongoing lifestyle choice in later years [36]. While research examining the psychological benefits of resistance training for youth is limited, emerging evidences suggests that physical activity interventions inclusive of resistance training may improve aspects of psychological well-being in young people [22]. Indeed, the authors of the 2014 International Consensus Statement on Youth Resistance Training suggest that resistance training can have a favorable influence on the psychological well-being of school-age youth provided that self-improvement and enjoyment remain central to the program [37]. In relation to the current study, the results suggest that ATLAS was not only able to improve muscular fitness among adolescent boys, but those effects in turn had a substantive ripple effect on boys' psychological well-being.

In spite of the notable effects of ATLAS in relation to psychological well-being, it is also likely that these intervention effects in relation to *overall* well-being may have been underestimated. Specifically, contemporary frameworks of well-being [38, 39] emphasize that well-being includes eudemonic *as well as* hedonic dimensions. Hedonic well-being includes the presence of positive affect, absence of negative affect, and satisfaction with one's life [38]. In light of the results of our previous 'process evaluation' of the ATLAS intervention [40], with participants reporting enjoying the sports sessions (particularly the

high intensity CrossFit-style workouts and group games), it seems likely the intervention may well have had an effect on hedonic well-being that was simply not captured in the current study. As such, future research would seem necessary to examine the extent to which lifestyle intervention programs such as ATLAS that target improved muscular fitness among adolescent boys result in improvements in both eudemonic and hedonic facets of well-being. *Implications*

The findings from this study have important implications for the design of health promotion interventions for adolescents from low-income communities. The results of a growing body of epidemiological evidence points to the health benefits of muscular fitness for adolescents [35]. Indeed, in recognition of this, international physical activity guidelines now recommend that adolescents participate in three bouts of muscle strengthening activities each week. The results of the current study lend added credence to these recommendations [35].

Strengths and limitations

Strengths of our study include the use of a cluster randomized controlled trial design, multilevel analysis, high levels of participant retention and intervention fidelity. Another notable strength of the study relates to the fact that the mediator linking the effects of the ATLAS intervention to measures of well-being was an objective test of muscular fitness. Notwithstanding these strengths, there are some limitations that should be acknowledged. First, as previously noted, while we assessed eudemonic well-being, we did not examine the extent to which hedonic well-being was bolstered (or not) in this study, and as such the results of this study might be considered to represent an incomplete picture of the efficacy of ATLAS to support the overall well-being. A second limitation of the study corresponds to the relatively homogenous population that was sampled, which limits the generalizability of our findings to other groups. Indeed, future research would appear worthwhile to examine the extent to which comparable program to ATLAS might be delivered and subsequently support improvements in psychological and physical health among adolescent girls as well.

Conclusions

The teachers delivering the ATLAS program were provided with professional development regarding SDT and ways in which to ensure their structured sports sessions satisfied the students' basic psychological needs. The results of this study provide causal evidence for the beneficial effects of satisfying boys' psychological needs for autonomy, improving their muscular fitness and reducing their recreational screen-time.

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Figure 1: Proposed mediation pathways and coefficients