An Internet-supported School Physical Activity Intervention in Low Socio-economic Status Communities: Results from the Activity and Motivation in Physical EDucation (AMPED) Cluster Randomised Controlled Trial

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Abstract

Objective: Quality physical education (PE) is the cornerstone of comprehensive school physical activity (PA) promotion programs. We tested the efficacy of a teacher professional learning intervention, delivered partially via the Internet, designed to maximise opportunities for students to be active during PE lessons and enhance adolescents' motivation towards PE and PA.

Methods: A two-arm cluster randomised controlled trial with teachers and Grade 8 students from secondary schools in low socio-economic areas of Western Sydney, Australia. The Activity and Motivation in Physical EDucation (AMPED) intervention for secondary school PE teachers included workshops, online learning, implementation tasks, and mentoring sessions. The primary outcome was the proportion of PE lesson time that students spent in MVPA, measured by accelerometers at baseline, post-intervention (7-8 months after baseline), and maintenance (14-15 months). Secondary outcomes included observed PE teachers' behavior during lessons, students' leisure-time PA, and students' motivation.

Results: Students (N = 1,421) from 14 schools completed baseline assessments and were included in linear mixed model analyses. The intervention had positive effects on students' MVPA during lessons. At post-intervention, the adjusted mean difference in the proportion of lesson time spent in MVPA was 5.58% ($p < 0.001$, approximately 4 min/lesson). During the maintenance phase, this effect was 2.64% ($p < 0.001$, approximately 2 min/lesson). The intervention had positive effects on teachers' behaviour, but did not impact students' motivation.

Conclusions: AMPED produced modest improvements in MVPA and compares favourably with previous interventions delivered exclusively face-to-face. Online teacher training could help facilitate widespread dissemination of professional learning interventions.

What are the new findings?

- AMPED was a professional learning intervention for secondary school teachers delivered partially online
- Teachers believed online learning was acceptable and useful
- AMPED increased adolescents' moderate-to-vigorous physical activity during school physical education lessons
- Observed increases in teaching quality were responsible for changes in student activity during lessons

Schools are potential venues for adolescent physical activity (PA) promotion [1 2]. The Centres for Disease Control recommend that schools implement comprehensive PA programs, built on a foundation of quality physical education (PE) [3]. Quality PE helps students develop the skills and motivation to be active outside school and later in life [4 5]. It also provides students with opportunities to be active during PE [3]; however, many lessons do not engage students in sufficient moderate-to-vigorous physical activity (MVPA) to benefit their health [6-8].

Teacher professional learning interventions can increase children's MVPA during primary and middle school PE lessons by 14% compared with usual practice [7]. There is, however, little evidence regarding interventions to increase MVPA in secondary school PE lessons. This paucity of efficacious interventions is problematic because the greatest declines in PA occur during early adolescence [9] and PE, when structured effectively, could represent an opportunity for these youth to participate in substantial amounts of MVPA during lessons.

In this study, we tested an intervention designed primarily to increase adolescents' MVPA during secondary school PE lessons. Intervention content was, therefore, based, in part, on efficacious programs conducted in primary and middle schools that helped teachers increase children's opportunities to be active during PE lessons [10-12]. Based on the notion that quality PE involves more than just high levels of MVPA during lessons, we also employed self-determination theory tenets to design an intervention that would also help teachers learn strategies that would motivate students over the long-term by increasing perceptions of autonomy, competence and belongingness (i.e., satisfying their basic psychological needs) [13 14]. As noted by Hobbs et al [4], this type of integrated approach acknowledges that interventions designed to increase students' MVPA during lessons should not do so at the expense of other PE outcomes, such as promoting students' autonomous motivation (e.g., enjoyment) [7].

Most school-based PA interventions have focused almost exclusively on face-to-face workshops [7 15]. To enhance teachers learning and the intervention's potential scalability, we incorporated a 'blended design', with a combination of face-to-face delivery and flexible online learning [16-18].

We conducted a cluster randomised controlled trial (RCT) in secondary schools located in low socio-economic areas of Western Sydney, Australia. This region has a large proportion of

youth from low socio-economic backgrounds [19 20], meaning they are at greater risk of physical inactivity compared with higher socio-economic status Australian adolescents [21]. We hypothesised that, compared with students in the control condition, students whose teacher participated in the intervention would:

1. spend a greater proportion of lesson time in MVPA (primary outcome);
2. spend a lower proportion of PE lessons being sedentary;
3. be more likely to attend and participate in PE lessons;
4. report greater basic psychological needs satisfaction in PE, as well as higher quality motivation towards PE and leisure-time MVPA; and
5. accumulate more MVPA and less sedentary time during leisure time.

Methods

Study Design and Participants

This study involved a prospectively registered (ACTRN12614000184673), two-arm, cluster RCT with allocation at the school level (1:1 ratio) (see Figure 1) [22]. We assessed outcomes for a cohort of students at baseline (start of Grade 8), post-intervention (end of Grade 8), and during a maintenance phase (mid-Grade 9). Australian Catholic University and New South Wales (NSW) Department of Education ethics boards approved this study.

School inclusion criteria included: (i) school with students enrolled in Grades 8 and 9; (ii) funded by the NSW Department of Education; (iii) permission granted by the principal, the head PE teacher, and at least one Grade 8 PE teacher; (iv) located in Western Sydney; (v) in a postal code with that was below the median on the Australian Bureau of Statistics' Index of Relative Socioeconomic Disadvantage.

In these schools, eligible participants included all PE teachers, as well as all students physically able to take part in Grade 8 PE. Parents provided consent prior to student enrolment.

We invited all schools that met our eligibility criteria, and from those indicating interest we aimed to purposively select a sample that was representative of the region in terms of school size and sex composition (i.e., single sex or co-educational). We match paired participating

schools according to socioeconomic disadvantage, school size, sex composition of PE classes, and the duration of PE lessons. Using a computer-based randomisation procedure, a blinded statistician randomised schools to the control or intervention condition from within each pair following baseline assessments.

Interventions

Supplementary File 1 contains details of the 'Activity and Motivation in Physical Education' (AMPED) intervention. AMPED had two aims: (i) to help teachers deliver lessons that maximised opportunities for MVPA; and (ii) to help teachers enhance their students' motivation towards PE. To maximise MVPA opportunities, teachers' learned strategies that were categorised under two headings: (a) 'Maximising Movement and Skill Development' and (b) 'Reducing Transition Time'. Strategies to enhance student motivation were organised under two further headings: (c) 'Building Competence' and (d) 'Supporting Students'.

Face-to-face workshops included brief presentations by the research team, but for much of these teachers worked independently on the project's website. This independent work was designed to help ensure teachers were comfortable working on the website, to facilitate later use. Throughout the entire intervention, teachers had access to online resources, a discussion forum, videos of good/poor practice (see Supplementary File 1c) and the project's mobile phone application, which included implementation and self-reflection prompts (see Supplementary File 1d).

Fidelity and Process Evaluation Measures

To assess implementation fidelity, trained observers, who were blinded to treatment allocation, rated a video recording of one randomly selected lesson for 64 teachers at baseline and at post-intervention. Ratings assessed the extent to which each teacher implemented strategies that were consistent with the four teaching principles described above [22].

Teachers completed intervention process evaluation measures of perceived usefulness. They also evaluated the AMPED website's usability [23].

Demographic and Anthropometric Information

Students reported their date of birth, sex, ethnic background [24], and family socioeconomic status [25]. We measured students' height and weight and calculated their body mass index (BMI) and BMI Z-score [26].

Outcome Measures

Primary Outcome

To measure MVPA during three PE lessons at each time point we employed ActiGraph accelerometers (GT1M, GT3X, and GT3X+ models; Fort Walton Beach, FL) attached at the right hip. We measured MVPA using 1 sec epochs to accurately capture the sporadic PA bouts that occur during PE [27]. We used vertical axis data to classify activity intensity using an MVPA cut point of ≥38.27 counts per 1sec (derived from a cut point of ≥574 counts per 15sec [28]). Research assistants recorded the start and finish times of each lesson (as indicated by the school bell), which were then used to filter the accelerometer data.

Secondary Outcomes

At each lesson, research assistants recorded the number of students participating, the number absent, and the number attending but not participating. Accelerometers assessed students' sedentary behaviour (< 1.67 counts per 1sec), as well as light (1.68-38.25 counts), moderate (38.26-66.85 counts), and vigorous (>66.86 counts) intensity activity during PE lessons [28]. We employed these same cut-offs to measure PA and sedentary behaviour during leisure time. We requested that students wear their accelerometer for five weekdays and two weekend days. To be included in the analyses, a student needed to provide valid data (≥ 8 h of wear time/day) for at least three days, including at least two weekdays. We also measured self-reported leisure time MVPA [29 30].

Motivational Mediators

Students completed questionnaires to assess their perceptions of teachers' motivationally supportive [31] and controlling [32] behaviours. They also responded to questionnaires

measuring their psychological needs satisfaction [33-35], autonomous motivation (e.g., intrinsic motivation), controlled motivation (e.g., pressure or guilt), and amotivation (i.e., lack of motivation) towards PE [36], as well as their motivation towards leisure-time PA [37 38].

Blinding

Research assistants blinded to school allocation collected all data. Students participating in the study were also blinded, but teachers were aware of their allocation to the intervention or control condition.

Sample Size

To ensure 80% power to detect an effect of d = 0.60 on the primary outcome (i.e., MVPA during PE lessons) [7], we required 90 participants for a non-clustered trial (two-tailed p = 0.05). We adjusted our calculations for class level clustering [39]; but, did not include school level clustering in our power analyses, as school level clustering of MVPA during lessons is typically negligible [40 41].

With an estimated class size of 22 participating students and an intra-class correlation of 0.63 [40 41], we required a sample of 1280 students to achieve 80% power. We aimed to recruit students from 14 schools, and estimated that 4.5 classes per school would participate (i.e., 1,386 students).

Statistical Analyses

Between November 2015 and October 2016 we conducted analyses using R software [42]. A researcher blinded to study hypotheses and allocation completed all analyses using generalised linear mixed models, following intention-to-treat principles. We assessed between-arm differences in changes by including an indicator variable for allocation (arm), a variable representing time (baseline, post-intervention, and/or maintenance), and their interaction (arm x time).

For the primary outcome, analysis included student MVPA data gathered from up to three lessons per student at each time point. We included four random intercept effects for: (i) lesson;

(ii) student; (iii) teacher; and (iv) class. When preliminary analyses suggested clustering at the school level, we included a fifth random intercept effect for this level.

As outlined in our protocol paper [22], we tested pre-specified moderators of intervention effects, including sex and ethnic background (categorical variables), as well as socio-economic status and baseline levels of MVPA and psychosocial variables (continuous variables). We explored significant interaction terms ($p < 0.1$) by testing differences in intervention effects across sub-groups stratified according to the moderator [43].

Finally, we used a cluster-bootstrapped based product-of-coefficients test [44] to test potential mediation pathways. For example, we examined whether teachers' implementation of the intervention, as indicated by increases in their use of AMPED teaching strategies, mediated the effect of the intervention on students' MVPA during lessons.

Results

Recruitment and Baseline Measures

Between February and April 2014, 23 of 64 eligible schools (36%) indicated interest in the study. We purposively selected 14 schools that were representative of the region, in terms of school population (sample mean = 828 students, region mean = 804 students). All schools in our sample were co-educational, but 22% of schools in the region were single-sex. Schools were located in postal codes with a mean decile rank of 2.1 on the Index of Relative Socioeconomic Disadvantage (mean of eligible schools = 2.4, range of eligible schools = 1 to 5).

Of the 101 PE teachers in the 14 schools, 94 (93.1%) provided consent, including all 60 Grade 8 PE teachers (100%). Of the 1,806 Grade 8 students enrolled, 1,421 (78.7%) gave their assent (and parental consent) and provided data during a baseline PE lesson. Demographics are shown in Table 1.

Fidelity and Process Evaluation

As shown in Supplementary File 2a, the intervention had significant, large positive effects on all categories of teacher behaviours that raters assessed, including: (a) Maximising Movement and Skill Development, (b) Reducing Transition Time, (c) Building Competence and (d) Supporting Students (all $p < .001$, $d > 1.6$).

Teachers rated the AMPED training as highly useful ($M = 4.82$ on 5-point scale, $SD = 0.38$). They also believed the website was user-friendly ($M = 4.60$ on 5-point scale, $SD = 0.48$). See Supplementary File 2b for details.

Primary Outcome

As shown in Table 2, at post-intervention the adjusted mean difference in the proportion of PE lesson time spent in MVPA was 5.66% (95% CI = 4.71 to 6.63) in favour of the intervention group ($p < 0.001$). Table 3 shows that during the maintenance phase this effect was 2.66% (95% CI = 1.13 to 4.17) in favour of the intervention group ($p = 0.001$).

Moderator analyses (see Supplementary File 3) showed that students whose teachers displayed poorer teaching at baseline showed greater increases in MVPA between baseline and post-intervention than did students whose teachers scored higher at baseline (all $p < 0.1$).

In terms of student variables, students from English/European ethnic backgrounds showed greater increases in MVPA during lessons compared with students from other ethnic backgrounds ($p < 0.05$). Students with high amotivation (i.e., lacking motivation), low autonomous motivation, low relatedness, and low levels of MVPA during baseline lessons also showed greater increases in MVPA from baseline to post-intervention compared with students high on these variables ($p < 0.1$). During the maintenance phase, girls' MVPA showed greater benefit than boys ($p = 0.001$) and the least active students showed greater improvements in MVPA than students who were more active at baseline ($p < 0.001$).

Mediator model analyses (see Supplementary File 4) showed that three categories of teacher behaviours ('Maximising Movement and Skill Development', 'Reducing Transition Time', and 'Supporting Students') were significant mediators of intervention effects on MVPA during lesson time ($p < 0.05$).

Secondary Outcomes

As shown in Table 2 (post-intervention) and Table 3 (maintenance) students' sedentary time during PE lesson time decreased ($p \leq 0.001$), while time spent in light, moderate, and vigorous PA increased ($p < 0.01$). The intervention, however, had no effect on the proportion of students who participated in PE (see Supplementary File 5).

At post-intervention (Table 2), accelerometer data showed a small increase in leisure-time MVPA by control group participants compared with intervention ($p = 0.06$), but this effect was not observed at maintenance (Table 3). No intervention effects were found for leisure-time sedentary time or light or vigorous PA.

Motivational Mediators

There were no significant intervention effects on PE motivational variables (see Supplementary File 6). In terms of leisure time motivation, at post-intervention, intervention students' controlled motivation did not change, but students in the control condition reported a trivial decrease in controlled motivation ($d = -0.018$, ($p = .005$)).

Discussion

According to the Centers for Disease Control [3], PE is the cornerstone of a comprehensive school physical activity program. Creating a motivationally supportive class environment and providing opportunities for students to be physically active during lessons are two elements of quality PE teaching. The AMPED intervention significantly increased students' MVPA during PE lessons and mechanisms responsible for these improvements were teachers' increased motivational support and strategies designed to minimise transition time and maximise opportunities for movement and skill development. The majority of teachers' completed all required professional learning elements and positive process evaluations showed that this Internet-supported professional learning intervention was feasible and acceptable.

Comparing AMPED intervention effects with previous interventions designed to increase MVPA in PE is challenging because of methodological differences. First, few studies have been conducted in the secondary school setting and, to our knowledge, none specifically targeted schools in low socio-economic areas [7]. Second, most previous studies have employed observational measures of students' MVPA during PE lessons (e.g., SOFIT) and these measures tend to overestimate MVPA compared with accelerometry [45]. Notwithstanding the noted sampling differences, the most meaningful comparisons likely involve an examination of relative effects. The AMPED intervention increased MVPA by about one-third compared with usual practice. This effect is larger than the 14% relative effect found in a recent meta-analysis of similar interventions [7].

During usual practice, students in our sample spent approximately 18% of lesson time in MVPA, which equates to approximately 11 minutes of MVPA per lesson (mean lesson duration = 63 minutes). AMPED's post-intervention effect, therefore, equates to approximately four extra minutes of MVPA per PE lesson. Beets and colleagues [46] recently proposed that interventions designed to increase youth MVPA should focus on 'expanding', 'extending' and 'enhancing' opportunities for participation. The AMPED intervention represents successful, albeit modest (e.g., 4 minutes/ PE lesson), 'enhancement' of an existing physical activity opportunity. However, contrary to previous self-determination theory-based interventions (that employed self-report measures) [13 14], our objectively-measured results indicated that AMPED did not increase students' leisure-time MVPA. Thus, on its own, AMPED is not an intervention that can increase adolescents' overall levels of MVPA. We, therefore, suggest that AMPED would be best implemented as an enhancement component of a comprehensive school physical activity program [3] that also includes other 'expansion' and 'extension' initiatives [46 47].

Limitations and Future Research

We employed relatively low intensity recruitment methods (e.g., emails to schools). Further research is needed to determine if more intensive marketing can increase response rates. Studies could also investigate if response rates are higher in a scale-up phase [48], when the burden of assessments is typically less than in an efficacy study (e.g., accelerometers, questionnaires).

Using video analysis to assess implementation fidelity is considered a gold standard method [49] and surpasses the quality of fidelity data gathered in most previous interventions in PE [7]. However, we only rated one lesson per teacher at baseline and post-intervention. Assessing more lessons could provide greater confidence regarding implementation fidelity.

AMPED employed a blended training approach (i.e., online and face-to-face) and teachers' positive responses suggest that Internet-based technology may provide a viable method to support interventions in schools. Future studies could compare blended delivery approaches with completely online learning. This research should be combined with cost-effectiveness analyses.

Research is required to examine the mechanisms of change in MVPA at the student level. Contrary to previous self-determination theory-based interventions [13 14], AMPED had no effect on students' self-reported motivational mediators. As shown in Supplementary File 2, teachers in our study tended to show greater improvements in the strategies associated with providing greater opportunities for MVPA compared with those designed to enhance student motivation. Future research could test the hypothesis that when teachers are presented with an integrated professional learning intervention, they may gravitate towards strategies that they perceive can be more easily implemented [50].

Investigations are also needed to understand why AMPED was most effective for girls and students with poor motivation. These students are often most at risk of decreasing MVPA during adolescence [9]; so, if the reasons for AMPED's effectiveness can be identified, these components could be emphasised in interventions targeting these populations [51].

Conclusion

The AMPED intervention was acceptable to teachers, feasible to deliver, and effectively increased adolescents' MVPA during PE lessons conducted in schools located in low socioeconomic areas. Internet-based tools may offer opportunities to support delivery of teacher professional learning programs designed to enhance adolescents' health and development.

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Competing Interests

The authors have no competing interests to declare. No financial disclosures were reported by the authors of this paper.

Author Contributions

CL and DL conceived the study and CL led its development and design. DL, AL, MK, IM, JG, LP, AB, GK, AM, and NN provided input on the design the intervention. KO, RW, FM, DC, DL, AL, EC and GK provided input on design of the study. EC, NN and TD designed and led the data analysis. CL drafted the manuscript. All authors edited and approved the final version of the paper.

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References

1. Hills AP, Dengel DR, Lubans DR. Supporting public health priorities: recommendations for physical education and physical activity promotion in schools. Prog. Cardiovasc. Dis. 2015;**57**(4):368-74
2. Drummond M, Drummond C, Dollman J, et al. Physical activity from early childhood to adolescence: a literature review of issues and interventions in disadvantaged populations. The Journal of Student Wellbeing 2011;**4**(2):17-31
3. Centers for Disease Control and Prevention. *Comprehensive School Physical Activity Programs: A Guide for Schools*. Atlanta, GA: U.S. Department of Health and Human Services, 2013.
4. Hobbs M, Daly-Smith A, McKenna J, et al. Reconsidering current objectives for physical activity within physical education: BMJ Publishing Group Ltd and British Association of Sport and Exercise Medicine, 2017.
5. United Nations Educational Scientific and Cultural Organization. Quality Physical Education: Guidelines for Policy-Makers. Paris: United Nations Educational, Scientific and Cultural Organization, 2015.
6. Office for Standards in Education Children's Services and Skills. *Beyond 2012 – Outstanding Physical Education for All: Physical Education in Schools*. Manchester, UK, 2013.
7. Lonsdale C, Rosenkranz RR, Peralta LR, et al. A systematic review and meta-analysis of interventions designed to increase moderate-to-vigorous physical activity in school physical education lessons. Prev. Med. 2013;**56**(2):152-61 doi: http://dx.doi.org/10.1016/j.ypmed.2012.12.004%5Bpublished Online First: Epub Date]|.
8. Fairclough S, Stratton G. Physical activity levels in middle and high school physical education: A review. Pediatr. Exerc. Sci. 2005;**17**(3):217
9. Sallis JF. Age-related decline in physical activity: A synthesis of human and animal studies. Med. Sci. Sports Exerc. 2000;**32**(9):1598-600
10. McKenzie TL, Sallis JF, Prochaska JJ, et al. Evaluation of a two-year middle-school physical education intervention: M-SPAN. Med. Sci. Sports Exerc. 2004;**36**(8):1382-88
11. McKenzie TL, Stone EJ, Feldman HA, et al. Effects of the CATCH physical education intervention: Teacher type and lesson location. Am. J. Prev. Med. 2001;**21**(2):101-09
12. Cohen KE, Morgan PJ, Plotnikoff RC, et al. Physical activity and skills intervention: SCORES cluster randomized controlled trial. Med. Sci. Sports Exerc. 2015;**47**(4):765-74
13. Cheon SH, Reeve J, Moon IS. Experimentally based, longitudinally designed, teacher-focused intervention to help physical education teachers be more autonomy supportive toward their students. J. Sport Exerc. Psychol. 2012;**34**(3):365-96
14. Chatzisarantis NLD, Hagger MS. Effects of an intervention based on self-determination theory on self-reported leisure-time physical activity participation. Psychology & Health 2008;**24**(1):29-48
15. Carson RL, Castelli DM, Kuhn ACP, et al. Impact of trained champions of comprehensive school physical activity programs on school physical activity offerings, youth physical activity and sedentary behaviors. Prev. Med. 2014;**69**:S12-S19

16. Allen JP, Pianta RC, Gregory A, et al. An interaction-based approach to enhancing secondary school instruction and student achievement. Science 2011;**333**(6045):1034-37
17. Ballew P, Castro S, Claus J, et al. Developing web-based training for public health practitioners: what can we learn from a review of five disciplines? Health Educ. Res. 2013;**28**(2):276-87
18. Lewis BA, Napolitano MA, Buman MP, et al. Future directions in physical activity intervention research: expanding our focus to sedentary behaviors, technology, and dissemination. J. Behav. Med. 2016:1-15 doi: 10.1007/s10865-016-9797-8[published Online First: Epub Date]|.
19. Australian Bureau of Statistics. Socioeconomic indexes for areas (SEIFA) Secondary Socioeconomic indexes for areas (SEIFA) 2011. http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/2033.0.55.001main+features100212011.
20. Australian Bureau of Statistics. Australian Social Trends. Secondary Australian Social Trends 2014. http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/4102.0main+features102014 - WHERE.
21. Hardy L, Mihrshahi S, Drayton B, et al. NSW Schools Physical Activity and Nutrition Survey (SPANS) 2015: Full Report. Sydney: NSW Department of Health., 2016.
22. Lonsdale C, Lester A, Owen KB, et al. An Internet-supported physical activity intervention delivered in secondary schools located in low socio-economic status communities: Study protocol for the Activity and Motivation in Physical Education (AMPED) cluster randomized controlled trial. BMC Public Health 2016;**16**(1):1
23. Bangor A, Kortum PT, Miller JT. An empirical evaluation of the system usability scale. Intl. Journal of Human–Computer Interaction 2008;**24**(6):574-94
24. Australian Bureau of Statistics. Australian Standard Classification of Languages. Canberra, 2011.
25. Currie C, Molcho M, Boyce W, et al. Researching health inequalities in adolescents: the development of the Health Behaviour in School-Aged Children (HBSC) family affluence scale. Soc. Sci. Med. 2008;**66**(6):1429-36
26. Flegal KM, Cole TJ. Construction of LMS parameters for the Centers for Disease Control and Prevention 2000 growth charts. Natl Health Stat Report 2013;**63**:1-4
27. Sanders T, Cliff DP, Lonsdale C. Measuring adolescent boys' physical activity: Bout length and the influence of accelerometer epoch length. PloS One 2014;**9**(3)
28. Evenson KR, Catellier DJ, Gill K, et al. Calibration of two objective measures of physical activity for children. J. Sports Sci. 2008;**26**(14):1557-65
29. Rangul V, Holmen TL, Kurtze N, et al. Reliability and validity of two frequently used self-administered physical activity questionnaires in adolescents. BMC Medical Research Methodology 2008;**8**(1):47
30. Prochaska JJ, Sallis JF, Long B. A physical activity screening measure for use with adolescents in primary care. Arch. Pediatr. Adolesc. Med. 2001;**155**(5):554-59
31. Belmont M, Skinner E, Wellborn J, et al. Teacher as social context: A measure of student perceptions of teacher provision of involvement, structure, and autonomy support. University of Rochester, Rochester, New York, NY 1988
32. Bartholomew K, Ntoumanis N, Thøgersen-Ntoumani C. The controlling interpersonal style in a coaching context: Development and initial validation of a psychometric scale. Journal of Sport and Exercise Psychology 2010;**32**(2):193-21

458 33. Standage M, Duda JL, Ntoumanis N. A model of contextual motivation in physical
459 education: Using constructs from self-determination and achievement goal
460 theories to predict physical activity intentions. J. Educ. Psychol. 2003;**95**(1):97-110
461 34. McAuley E, Duncan T, Tammen VV. Psychometric properties of the Intrinsic
462 Motivation Inventory in a competitive sport setting: A confirmatory factor
463 analysis. . Res. Q. Exerc. Sport 1989;**60**(1):48–58
464 35. Richer SF, Vallerand RJ. Construction et validation de l'échelle du sentiment
465 d'appartenance sociale (ÉSAS) [Construction and validaton of the ÉSAS the
466 relatedness feelings scale]. European Review of Applied Psychology
467 1998;**48**(2):129-38
468 36. Lonsdale C, Sabiston CM, Taylor IM, et al. Measuring student motivation for physical
469 education: Examining the psychometric properties of the Perceived Locus of
470 Causality Questionnaire and the Situational Motivation Scale. Psychology of Sport
471 and Exercise 2011;**12**(3):284–92
472 37. Markland D, Tobin V. A modification to the Behavioural Regulation in Exercise
473 Questionnaire to include an assessment of amotivation. J. Sport Exerc. Psychol.
474 2004;**26**(2):191-96
475 38. Dishman RK, McIver KL, Dowda M, et al. Motivation and behavioral regulation of
476 physical activity in middle-school students. Med. Sci. Sports Exerc. 2015;**47**(9)
477 39. Campbell MK, Elbourne DR, Altman DG. CONSORT statement: Extension to cluster
478 randomised trials. Br. Med. J. 2004;**328**:702-08
479 40. Aelterman N, Vansteenkiste M, Van Keer H, et al. Students' objectively measured
480 physical activity levels and engagement as a function of between-class and
481 between-student differences in motivation toward physical education. J. Sport
482 Exerc. Psychol. 2012;**34**(4):457
483 41. Lonsdale C, Rosenkranz RR, Sanders T, et al. A cluster randomized controlled trial of
484 strategies to increase adolescents' physical activity and motivation in physical
485 education: Results of the Motivating Active Learning in Physical Education (MALP)
486 trial. Prev. Med. 2013;**57**(5):696-702
487 42. lme4: Linear Mixed-Effects Models using 'Eigen' and S4. R package version 1.1-12
488 [program], 2016.
489 43. Assmann SF, Pocock SJ, Enos LE, et al. Subgroup analysis and other (mis) uses of
490 baseline data in clinical trials. The Lancet 2000;**355**(9209):1064-69
491 44. Krull JL, MacKinnon DP. Multilevel modeling of individual and group level mediated
492 effects. Multivariate Behavioral Research 2001;**36**:249-77
493 45. Hollis JL, Williams AJ, Sutherland R, et al. A systematic review and meta-analysis of
494 moderate-to-vigorous physical activity levels in elementary school physical
495 education lessons. Prev. Med. 2016;**86**:34-54
496 46. Beets MW, Okely A, Weaver RG, et al. The theory of expanded, extended, and enhanced
497 opportunities for youth physical activity promotion. International journal of
498 behavioral nutrition and physical activity 2016;**13**(1):120
499 47. Sutherland R, Campbell E, Lubans DR, et al. 'Physical Activity 4 Everyone'school-based
500 intervention to prevent decline in adolescent physical activity levels: 12 month
501 (mid-intervention) report on a cluster randomised trial. Br. J. Sports Med.
502 2016;**50**(8):488-95
503 48. McKay HA, Macdonald HM, Nettlefold L, et al. Action Schools! BC implementation:
504 from efficacy to effectiveness to scale-up. Br. J. Sports Med. 2014:bjsports-2013-
505 093361

506 49. Glasgow RE, Emont S, Miller DC. Assessing delivery of the five 'As' for patient-centered
507 counseling. Health Promotion International 2006;**21**(3):245-55 doi:
508 10.1093/heapro/dal017[published Online First: Epub Date]|.
509 50. Reeve J, Cheon SH. Teachers become more autonomy supportive after they believe it is
510 easy to do. Psychology of Sport and Exercise 2016;**22**:178-89
511 51. Guagliano JM, Lonsdale C, Kolt GS, et al. Increasing girls' physical activity during a
512 short-term organized youth sport basketball program: A randomized controlled
513 trial. J. Sci. Med. Sport 2015

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516 Table 1: Baseline Characteristics.

Characteristic	Intervention Group	Control Group
Schools		
Index of Relative Socioeconomic Disadvantage for the school's postcode	2.14	2.14
Estimated Grade 8 enrolment in year prior to study (n)	126.14	121.43
Schools with co-ed PE lessons (%)	85.71	85.71
Duration of PE lessons (minutes/lesson)	63.57	62.14
Teachers		
Total participants (n)	47	47
Sex (%)		
Male	55.32	48.94
Female	44.68	51.06
Country of Birth (%)		
Australia	80.85	88.88
Other	19.15	11.12
Overall job satisfaction	8.51 (1.23)	7.96 (1.48)
Years of teaching experience	7.80 (6.45)	8.84 (6.57)
Students		
Total participants (n)	693	728
Sex (%)		
Boys	51.90	59.00
Girls	48.10	41.00
Country of Birth (%)		
Australia	77.90	81.30
Other	22.10	18.70
Age, years	12.96 (0.56)	12.90 (0.52)
Ethnicity (%)		
English & European	58.30	56.70

Aboriginal or Torres Strait Islander origin	9.0	10.10
Others	32.70	32.20
Height, m	159.80 (7.91)	159.81 (8.06)
Weight, kg	56.94 (14.86)	56.70 (15.03)
Student BMI category (%)		
Underweight	24.30	24.80
Healthy weight	50.20	50.80
Overweight	18.40	17.40
Obese	7.20	7.10
Daily total physical activity (minutes/day)		
Sedentary	592.63 (117.11)	586.32 (105.68)
Light intensity	90.56 (25.62)	88.94 (24.29)
Moderate intensity	31.35 (11.41)	28.99 (9.98)
Vigorous intensity	20.50 (11.61)	19.45 (11.45)
MVPA	51.85 (20.31)	48.45 (19.04)
Accelerometer wear time	735.04 (119.14)	723.71 (107.81)

Note: Except where indicated, values represent sample means, with standard deviations in parentheses. BMI = body mass index (kg/m^2). MVPA = moderate-to-vigorous physical activity. Teacher job satisfaction was measured using a 10-point Likert scale (1 = *dissatisfied*, 10 = *satisfied*).

Table 2. Changes in behavioural outcomes at post-intervention assessment.

Measure	Control, Mean (SD)				*p*	Intervention, Mean (SD)				*p*	Intervention-Control Adjusted Difference in Change		*p*	Cohen's *d*	ICC			
	Baseline		Post-intervention			Baseline		Post-intervention							Student	Class	Teacher	School
	n	Estimate (*SD*)	*n*	Estimate (*SD*)		*n*	Estimate (*SD*)	*n*	Estimate (*SD*)		Estimate	95% CI						
PE Lessons - accelerometer																		
MVPA	728	18.85 (7.17)	629	18.48 (8.20)	<0.001	693	18.19 (6.15)	623	24.06 (8.99)	<0.001	5.66	4.71 to 6.63	<0.001	0.85	0.18	0.09	0.07	0.07
Moderate PA	728	8.44 (3.13)	629	8.80 (3.71)	<0.001	693	8.82 (2.99)	630	11.70 (3.87)	<0.001	2.54	2.07 to 3.01	<0.001	0.83	0.10	0.09	0.08	0.06
Vigorous PA	728	10.44 (5.06)	629	9.72 (5.15)	0.110	693	9.43 (4.01)	630	12.43 (6.05)	<0.001	3.09	2.48 to 3.71	<0.001	0.68	0.25	0.07	0.06	0.06
Sedentary	728	58.16 (9.84)	629	56.52 (12.83)	<0.001	693	57.88 (9.35)	630	46.96 (12.69)	<0.001	-11.11	-12.63 to -9.59	<0.001	-1.16	0.10	0.12	0.08	0.05
Light PA	728	23.02 (5.48)	629	25.01 (6.75)	0.031	693	23.93 (5.30)	630	29.05 (7.09)	<0.001	5.36	4.46 to 6.24	<0.001	0.99	0.09	0.09	0.07	-
Leisure-time - accelerometer																		
MVPA	488	7.24 (4.09)	274	7.47 (4.89)	0.003	520	7.59 (4.49)	345	7.27 (3.97)	0.363	-1.09	-1.87 to -0.31	0.006	-0.25	0.39	0.00	0.05	-
Moderate PA	488	4.24 (2.32)	274	4.50 (3.10)	0.001	520	4.49 (2.68)	345	4.24 (2.32)	0.848	-0.70	-1.17 to -0.22	0.004	-0.28	0.38	0.00	0.06	-
Vigorous PA	488	3.00 (2.25)	274	2.96 (2.32)	0.045	520	3.10 (2.31)	345	3.03 (2.09)	0.113	-0.39	-0.79 to 0.01	0.057	-0.17	0.41	0.00	0.04	-
Sedentary	488	80.61 (6.89)	274	81.40 (7.60)	0.201	520	80.40 (7.37)	345	81.60 (6.68)	0.045	0.92	-0.28 to 2.13	0.133	0.13	0.43	0.00	0.05	-
Light PA	488	12.15 (3.77)	274	11.13 (3.87)	0.001	520	12.01 (4.05)	345	11.12 (3.72)	0.013	0.17	-0.47 to 0.81	0.607	0.04	0.42	0.00	0.03	-
Leisure-time - questionnaire																		
Physical activity frequency	579	3.47 (1.22)	465	3.31 (1.18)	0.089	548	3.35 (1.18)	487	3.29 (1.21)	0.605	0.07	-0.15 to 0.29	0.487	0.06	0.43	0.03	0.04	-
Physical activity duration	258	4.56 (2.04)	202	4.41 (1.95)	0.539	281	4.46 (1.86)	226	4.27 (1.89)	0.191	-0.07	-0.46 to 0.32	0.706	-0.04	0.50	0.00	0.00	0.03

Note: ICC = intra-class correlation MVPA = moderate to vigorous physical activity. All accelerometer values represent the proportion of time spent in each intensity of activity (%). Questionnaire data was obtained using Likert scales; for frequency, the scale ranged from 1= *once per month* to 5 = *every day*. For duration, the scale ranged from 1 = *none* to 8 = *more than 8 hours per week*. Cohen's *d* = adjusted difference in change / pooled *SD* at baseline. "-" indicates that adjustments for school level clustering did not lead to a significant decrease in the chi-squared value. Primary outcome data were collected from 14 schools (73 classes) at baseline and post-intervention. All PE lesson analyses include the following covariates: (i) temperature at the start time of the lesson, (ii) the type of activity included in the lesson, (iii) and the timing of accelerometer fitting for the lesson (the student arrived at lesson wearing an accelerometer or was fitted at started of lesson).

Table 3. Changes in behavioural outcomes at maintenance assessment.

Measure	Control, Mean (SD)				*p*	Intervention, Mean (SD)				*p*	Intervention-Control Adjusted Difference in Change		*p*	Cohen's *d*	ICC			
	Baseline		Maintenance			Baseline		Maintenance							Student	Class	Teacher	School
	n	Estimate (*SD*)	*n*	Estimate (*SD*)		*n*	Estimate (*SD*)	*n*	Estimate (*SD*)		Estimate	95% CI						
PE Lessons - accelerometer																		
MVPA	728	18.85 (7.17)	504	17.92 (9.52)	0.772	693	18.19 (6.15)	494	22.44 (9.29)	0.001	2.66	1.13 to 4.17	0.001	0.40	0.15	0.21	0.14	-
Sedentary	728	58.16 (9.84)	504	58.85 (14.81)	0.603	693	57.88 (9.35)	494	50.22 (13.82)	<0.001	-3.74	-6.11 to -1.38	0.002	-0.39	0.10	0.22	0.14	0.04
Light PA	728	23.02 (5.48)	504	23.23 (7.61)	0.475	693	23.93 (5.30)	494	27.40 (7.63)	<0.001	1.29	0.19 to 2.38	0.023	0.24	0.11	0.14	0.08	0.07
Moderate PA	728	8.44 (3.13)	504	8.28 (4.09)	0.168	693	8.82 (2.99)	494	10.77 (3.97)	<0.001	1.06	0.46 to 1.69	0.001	0.35	0.10	0.17	0.13	0.05
Vigorous PA	728	10.44 (5.06)	504	9.64 (6.16)	0.654	693	9.43 (4.01)	494	11.69 (6.52)	0.008	1.51	0.56 to 2.45	0.002	0.33	0.20	0.19	0.10	-
Leisure-time - accelerometer																		
MVPA	488	7.24 (4.09)	184	7.05 (4.14)	0.415	520	7.59 (4.49)	236	6.96 (4.53)	0.586	-0.14	-0.73 to 0.46	0.660	-0.03	0.34	0.02	0.01	0.01
Sedentary	488	80.61(6.89)	184	81.96 (7.31)	0.158	520	80.40(7.37)	236	82.39 (7.55)	0.027	0.02	-0.99 to 0.95	0.964	0.00	0.30	0.03	0.01	0.02
Light PA	488	12.15(3.77)	184	10.99 (4.26)	0.002	520	12.01(4.05)	236	10.65 (4.31)	0.006	0.08	-0.42 to 0.58	0.752	0.02	0.25	0.04	0.00	0.03
Moderate PA	488	4.24(2.32)	184	4.20 (2.39)	0.240	520	4.49(2.68)	236	4.11 (2.61)	0.889	-0.18	-0.54 to 0.19	0.354	-0.07	0.28	0.01	0.02	-
Vigorous PA	488	3.00(2.25)	184	2.85 (2.39)	0.845	520	3.10(2.31)	236	2.85 (2.51)	0.479	0.03	-0.27 to 0.34	0.823	0.01	0.34	0.02	0.00	0.01
Leisure-time Physical Activity - questionnaire																		
Frequency	579	3.47 (1.22)	411	3.14 (1.20)	0.020	584	3.35 (1.18)	437	3.07 (1.20)	0.073	0.03	-0.10 to 0.19	0.652	0.03	0.41	0.06	0.00	-
Duration	258	4.56 (2.04)	179	4.34 (1.98)	0.131	281	4.46 (1.86)	208	4.09 (1.89)	0.112	0.01	-0.24 to 0.24	0.997	-0.04	0.50	0.00	0.00	0.03

Note: ICC = intra-class correlation MVPA = moderate to vigorous physical activity. All accelerometer values represent the proportion of time spent in each intensity of activity (%). Questionnaire data was obtained using Likert scales; for frequency, the scale ranged from 1= *once per month* to 5 = *every day*. For duration, the scale ranged from 1 = *none* to 8 = *more than 8 hours per week*. Cohen's *d* = adjusted difference in change / pooled *SD* at baseline. "-" indicates that adjustments for school level clustering did not lead to a significant decrease in the chi-squared value. Primary outcome data were collected from 14 schools (73 classes) at baseline and maintenance. All PE lesson analyses include the following covariates: (i) temperature at the start time of the lesson, (ii) the type of activity included in the lesson, (iii) and the timing of accelerometer fitting for the lesson (the student arrived at lesson wearing an accelerometer or was fitted at started of lesson).