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

1   Schools are potential venues for adolescent physical activity (PA) promotion [1 2]. The Centres

2   for Disease Control recommend that schools implement comprehensive PA programs, built on

3   a foundation of quality physical education (PE) [3]. Quality PE helps students develop the

4   skills and motivation to be active outside school and later in life [4 5]. It also provides students

5   with opportunities to be active during PE [3]; however, many lessons do not engage students in

6   sufficient moderate-to-vigorous physical activity (MVPA) to benefit their health [6-8].

7

8   Teacher professional learning interventions can increase children's MVPA during primary and

9   middle school PE lessons by 14% compared with usual practice [7]. There is, however, little

10   evidence regarding interventions to increase MVPA in secondary school PE lessons. This

11   paucity of efficacious interventions is problematic because the greatest declines in PA occur

12   during early adolescence [9] and PE, when structured effectively, could represent an

13   opportunity for these youth to participate in substantial amounts of MVPA during lessons.

14

15   In this study, we tested an intervention designed primarily to increase adolescents' MVPA

16   during secondary school PE lessons. Intervention content was, therefore, based, in part, on

17   efficacious programs conducted in primary and middle schools that helped teachers increase

18   children's opportunities to be active during PE lessons [10-12]. Based on the notion that quality

19   PE involves more than just high levels of MVPA during lessons, we also employed self-

20   determination theory tenets to design an intervention that would also help teachers learn

21   strategies that would motivate students over the long-term by increasing perceptions of

22   autonomy, competence and belongingness (i.e., satisfying their basic psychological needs) [13

23   14]. As noted by Hobbs et al [4], this type of integrated approach acknowledges that

24   interventions designed to increase students' MVPA during lessons should not do so at the

25   expense of other PE outcomes, such as promoting students' autonomous motivation (e.g.,

26   enjoyment) [7].

27

28   Most school-based PA interventions have focused almost exclusively on face-to-face

29   workshops [7 15]. To enhance teachers learning and the intervention's potential scalability, we

30   incorporated a 'blended design', with a combination of face-to-face delivery and flexible online

31   learning [16-18].

32

33   We conducted a cluster randomised controlled trial (RCT) in secondary schools located in low

34   socio-economic areas of Western Sydney, Australia. This region has a large proportion of

35   youth from low socio-economic backgrounds [19 20], meaning they are at greater risk of

36   physical inactivity compared with higher socio-economic status Australian adolescents [21].

37   We hypothesised that, compared with students in the control condition, students whose teacher

38   participated in the intervention would:

39   1.   spend a greater proportion of lesson time in MVPA (primary outcome);

40   2.   spend a lower proportion of PE lessons being sedentary;

41   3.   be more likely to attend and participate in PE lessons;

42   4.   report greater basic psychological needs satisfaction in PE, as well as higher quality

43   motivation towards PE and leisure-time MVPA; and

44   5.   accumulate more MVPA and less sedentary time during leisure time.

45

46   **Methods**

47

48   **Study Design and Participants**

49

50   This study involved a prospectively registered (ACTRN12614000184673), two-arm, cluster

51   RCT with allocation at the school level (1:1 ratio) (see Figure 1) [22]. We assessed outcomes

52   for a cohort of students at baseline (start of Grade 8), post-intervention (end of Grade 8), and

53   during a maintenance phase (mid-Grade 9). Australian Catholic University and New South

54   Wales (NSW) Department of Education ethics boards approved this study.

55

56   School inclusion criteria included: (i) school with students enrolled in Grades 8 and 9; (ii)

57   funded by the NSW Department of Education; (iii) permission granted by the principal, the

58   head PE teacher, and at least one Grade 8 PE teacher; (iv) located in Western Sydney; (v) in a

59   postal code with that was below the median on the Australian Bureau of Statistics' Index of

60   Relative Socioeconomic Disadvantage.

61   In these schools, eligible participants included all PE teachers, as well as all students physically

62   able to take part in Grade 8 PE. Parents provided consent prior to student enrolment.

63

64   We invited all schools that met our eligibility criteria, and from those indicating interest we

65   aimed to purposively select a sample that was representative of the region in terms of school

66   size and sex composition (i.e., single sex or co-educational). We match paired participating

67 schools according to socioeconomic disadvantage, school size, sex composition of PE classes,

68 and the duration of PE lessons. Using a computer-based randomisation procedure, a blinded

69 statistician randomised schools to the control or intervention condition from within each pair

70 following baseline assessments.

71

72 **Interventions**

73

74 Supplementary File 1 contains details of the 'Activity and Motivation in Physical Education'

75 (AMPED) intervention. AMPED had two aims: (i) to help teachers deliver lessons that

76 maximised opportunities for MVPA; and (ii) to help teachers enhance their students'

77 motivation towards PE. To maximise MVPA opportunities, teachers' learned strategies that

78 were categorised under two headings: (a) 'Maximising Movement and Skill Development' and

79 (b) 'Reducing Transition Time'. Strategies to enhance student motivation were organised under

80 two further headings: (c) 'Building Competence' and (d) 'Supporting Students'.

81

82 Face-to-face workshops included brief presentations by the research team, but for much of

83 these teachers worked independently on the project's website. This independent work was

84 designed to help ensure teachers were comfortable working on the website, to facilitate later

85 use. Throughout the entire intervention, teachers had access to online resources, a discussion

86 forum, videos of good/poor practice (see Supplementary File 1c) and the project's mobile

87 phone application, which included implementation and self-reflection prompts (see

88 Supplementary File 1d).

89

90 **Fidelity and Process Evaluation Measures**

91

92 To assess implementation fidelity, trained observers, who were blinded to treatment allocation,

93 rated a video recording of one randomly selected lesson for 64 teachers at baseline and at post-

94 intervention. Ratings assessed the extent to which each teacher implemented strategies that

95 were consistent with the four teaching principles described above [22].

96

97 Teachers completed intervention process evaluation measures of perceived usefulness. They

98 also evaluated the AMPED website's usability [23].

99

100 **Demographic and Anthropometric Information**

101

102   Students reported their date of birth, sex, ethnic background [24], and family socioeconomic

103   status [25]. We measured students' height and weight and calculated their body mass index

104   (BMI) and BMI Z-score [26].

105

106   **Outcome Measures**

107

108   *Primary Outcome*

109

110   To measure MVPA during three PE lessons at each time point we employed ActiGraph

111   accelerometers (GT1M, GT3X, and GT3X+ models; Fort Walton Beach, FL) attached at the

112   right hip. We measured MVPA using 1 sec epochs to accurately capture the sporadic PA bouts

113   that occur during PE [27]. We used vertical axis data to classify activity intensity using an

114   MVPA cut point of ≥ 38.27 counts per 1sec (derived from a cut point of ≥ 574 counts per 15sec

115   [28]). Research assistants recorded the start and finish times of each lesson (as indicated by the

116   school bell), which were then used to filter the accelerometer data.

117

118   *Secondary Outcomes*

119

120   At each lesson, research assistants recorded the number of students participating, the number

121   absent, and the number attending but not participating. Accelerometers assessed students'

122   sedentary behaviour (< 1.67 counts per 1sec), as well as light (1.68-38.25 counts), moderate

123   (38.26-66.85 counts), and vigorous (>66.86 counts) intensity activity during PE lessons [28].

124   We employed these same cut-offs to measure PA and sedentary behaviour during leisure time.

125   We requested that students wear their accelerometer for five weekdays and two weekend days.

126   To be included in the analyses, a student needed to provide valid data (≥ 8 h of wear time/day)

127   for at least three days, including at least two weekdays. We also measured self-reported leisure

128   time MVPA [29 30].

129

130   *Motivational Mediators*

131

132   Students completed questionnaires to assess their perceptions of teachers' motivationally

133   supportive [31] and controlling [32] behaviours. They also responded to questionnaires

134 measuring their psychological needs satisfaction [33-35], autonomous motivation (e.g.,

135 intrinsic motivation), controlled motivation (e.g., pressure or guilt), and amotivation (i.e., lack

136 of motivation) towards PE [36], as well as their motivation towards leisure-time PA [37 38].

137

138 **Blinding**

139

140 Research assistants blinded to school allocation collected all data. Students participating in the

141 study were also blinded, but teachers were aware of their allocation to the intervention or

142 control condition.

143

144 **Sample Size**

145

146 To ensure 80% power to detect an effect of $d = 0.60$ on the primary outcome (i.e., MVPA

147 during PE lessons) [7], we required 90 participants for a non-clustered trial (two-tailed $p =$

148 0.05). We adjusted our calculations for class level clustering [39]; but, did not include school

149 level clustering in our power analyses, as school level clustering of MVPA during lessons is

150 typically negligible [40 41].

151

152 With an estimated class size of 22 participating students and an intra-class correlation of 0.63

153 [40 41], we required a sample of 1280 students to achieve 80% power. We aimed to recruit

154 students from 14 schools, and estimated that 4.5 classes per school would participate (i.e.,

155 1,386 students).

156

157 **Statistical Analyses**

158

159 Between November 2015 and October 2016 we conducted analyses using R software [42]. A

160 researcher blinded to study hypotheses and allocation completed all analyses using generalised

161 linear mixed models, following intention-to-treat principles. We assessed between-arm

162 differences in changes by including an indicator variable for allocation (arm), a variable

163 representing time (baseline, post-intervention, and/or maintenance), and their interaction (arm x

164 time).

165

166 For the primary outcome, analysis included student MVPA data gathered from up to three

167 lessons per student at each time point. We included four random intercept effects for: (i) lesson;

168 (ii) student; (iii) teacher; and (iv) class. When preliminary analyses suggested clustering at the

169 school level, we included a fifth random intercept effect for this level.

170

171 As outlined in our protocol paper [22], we tested pre-specified moderators of intervention

172 effects, including sex and ethnic background (categorical variables), as well as socio-economic

173 status and baseline levels of MVPA and psychosocial variables (continuous variables). We

174 explored significant interaction terms ($p < 0.1$) by testing differences in intervention effects

175 across sub-groups stratified according to the moderator [43].

176

177 Finally, we used a cluster-bootstrapped based product-of-coefficients test [44] to test potential

178 mediation pathways. For example, we examined whether teachers' implementation of the

179 intervention, as indicated by increases in their use of AMPED teaching strategies, mediated the

180 effect of the intervention on students' MVPA during lessons.

181

182 **Results**

183

184 **Recruitment and Baseline Measures**

185

186 Between February and April 2014, 23 of 64 eligible schools (36%) indicated interest in the

187 study. We purposively selected 14 schools that were representative of the region, in terms of

188 school population (sample mean = 828 students, region mean = 804 students). All schools in

189 our sample were co-educational, but 22% of schools in the region were single-sex. Schools

190 were located in postal codes with a mean decile rank of 2.1 on the Index of Relative

191 Socioeconomic Disadvantage (mean of eligible schools = 2.4, range of eligible schools = 1 to

192 5).

193

194 Of the 101 PE teachers in the 14 schools, 94 (93.1%) provided consent, including all 60 Grade

195 8 PE teachers (100%). Of the 1,806 Grade 8 students enrolled, 1,421 (78.7%) gave their assent

196 (and parental consent) and provided data during a baseline PE lesson. Demographics are shown

197 in Table 1.

198

199 **Fidelity and Process Evaluation**

200

201   As shown in Supplementary File 2a, the intervention had significant, large positive effects on
202   all categories of teacher behaviours that raters assessed, including: (a) Maximising Movement
203   and Skill Development, (b) Reducing Transition Time, (c) Building Competence and (d)
204   Supporting Students (all $p < .001$, $d > 1.6$).
205
206   Teachers rated the AMPED training as highly useful ($M = 4.82$ on 5-point scale, $SD = 0.38$).
207   They also believed the website was user-friendly ($M = 4.60$ on 5-point scale, $SD = 0.48$). See
208   Supplementary File 2b for details.
209
210   **Primary Outcome**
211
212   As shown in Table 2, at post-intervention the adjusted mean difference in the proportion of PE
213   lesson time spent in MVPA was 5.66% (95% CI = 4.71 to 6.63) in favour of the intervention
214   group ($p < 0.001$). Table 3 shows that during the maintenance phase this effect was 2.66%
215   (95% CI = 1.13 to 4.17) in favour of the intervention group ($p = 0.001$).
216
217   Moderator analyses (see Supplementary File 3) showed that students whose teachers displayed
218   poorer teaching at baseline showed greater increases in MVPA between baseline and post-
219   intervention than did students whose teachers scored higher at baseline (all $p < 0.1$).
220
221   In terms of student variables, students from English/European ethnic backgrounds showed
222   greater increases in MVPA during lessons compared with students from other ethnic
223   backgrounds ($p < 0.05$). Students with high amotivation (i.e., lacking motivation), low
224   autonomous motivation, low relatedness, and low levels of MVPA during baseline lessons also
225   showed greater increases in MVPA from baseline to post-intervention compared with students
226   high on these variables ($p < 0.1$). During the maintenance phase, girls' MVPA showed greater
227   benefit than boys ($p = 0.001$) and the least active students showed greater improvements in
228   MVPA than students who were more active at baseline ($p < 0.001$).
229
230   Mediator model analyses (see Supplementary File 4) showed that three categories of teacher
231   behaviours ('Maximising Movement and Skill Development', 'Reducing Transition Time', and
232   'Supporting Students') were significant mediators of intervention effects on MVPA during
233   lesson time ($p < 0.05$).
234

235 **Secondary Outcomes**

236

237 As shown in Table 2 (post-intervention) and Table 3 (maintenance) students' sedentary time

238 during PE lesson time decreased ($p \leq 0.001$), while time spent in light, moderate, and vigorous

239 PA increased ($p < 0.01$). The intervention, however, had no effect on the proportion of students

240 who participated in PE (see Supplementary File 5).

241

242 At post-intervention (Table 2), accelerometer data showed a small increase in leisure-time

243 MVPA by control group participants compared with intervention ($p = 0.06$), but this effect was

244 not observed at maintenance (Table 3). No intervention effects were found for leisure-time

245 sedentary time or light or vigorous PA.

246

247

248 **Motivational Mediators**

249

250 There were no significant intervention effects on PE motivational variables (see Supplementary

251 File 6). In terms of leisure time motivation, at post-intervention, intervention students'

252 controlled motivation did not change, but students in the control condition reported a trivial

253 decrease in controlled motivation ($d = -0.018$, ($p = .005$)).

254

255 <div align="center">**Discussion**</div>

256

257 According to the Centers for Disease Control [3], PE is the cornerstone of a comprehensive

258 school physical activity program. Creating a motivationally supportive class environment and

259 providing opportunities for students to be physically active during lessons are two elements of

260 quality PE teaching. The AMPED intervention significantly increased students' MVPA during

261 PE lessons and mechanisms responsible for these improvements were teachers' increased

262 motivational support and strategies designed to minimise transition time and maximise

263 opportunities for movement and skill development. The majority of teachers' completed all

264 required professional learning elements and positive process evaluations showed that this

265 Internet-supported professional learning intervention was feasible and acceptable.

266

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

277

278 During usual practice, students in our sample spent approximately 18% of lesson time in
279 MVPA, which equates to approximately 11 minutes of MVPA per lesson (mean lesson duration
280 = 63 minutes). AMPED's post-intervention effect, therefore, equates to approximately four
281 extra minutes of MVPA per PE lesson. Beets and colleagues [46] recently proposed that
282 interventions designed to increase youth MVPA should focus on 'expanding', 'extending' and
283 'enhancing' opportunities for participation. The AMPED intervention represents successful,
284 albeit modest (e.g., 4 minutes/ PE lesson), 'enhancement' of an existing physical activity
285 opportunity. However, contrary to previous self-determination theory-based interventions (that
286 employed self-report measures) [13 14], our objectively-measured results indicated that
287 AMPED did not increase students' leisure-time MVPA. Thus, on its own, AMPED is not an
288 intervention that can increase adolescents' overall levels of MVPA. We, therefore, suggest that
289 AMPED would be best implemented as an enhancement component of a comprehensive school
290 physical activity program [3] that also includes other 'expansion' and 'extension' initiatives [46
291 47].

292

293

294 *Limitations and Future Research*

295

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

301

302 Using video analysis to assess implementation fidelity is considered a gold standard method

303 [49] and surpasses the quality of fidelity data gathered in most previous interventions in PE [7].

304 However, we only rated one lesson per teacher at baseline and post-intervention. Assessing

305 more lessons could provide greater confidence regarding implementation fidelity.

306

307 AMPED employed a blended training approach (i.e., online and face-to-face) and teachers'

308 positive responses suggest that Internet-based technology may provide a viable method to

309 support interventions in schools. Future studies could compare blended delivery approaches

310 with completely online learning. This research should be combined with cost-effectiveness

311 analyses.

312

313 Research is required to examine the mechanisms of change in MVPA at the student level.

314 Contrary to previous self-determination theory-based interventions [13 14], AMPED had no

315 effect on students' self-reported motivational mediators. As shown in Supplementary File 2,

316 teachers in our study tended to show greater improvements in the strategies associated with

317 providing greater opportunities for MVPA compared with those designed to enhance student

318 motivation. Future research could test the hypothesis that when teachers are presented with an

319 integrated professional learning intervention, they may gravitate towards strategies that they

320 perceive can be more easily implemented [50].

321

322 Investigations are also needed to understand why AMPED was most effective for girls and

323 students with poor motivation. These students are often most at risk of decreasing MVPA

324 during adolescence [9]; so, if the reasons for AMPED's effectiveness can be identified, these

325 components could be emphasised in interventions targeting these populations [51].

326

327 *Conclusion*

328

329 The AMPED intervention was acceptable to teachers, feasible to deliver, and effectively

330 increased adolescents' MVPA during PE lessons conducted in schools located in low

331 socioeconomic areas. Internet-based tools may offer opportunities to support delivery of

332 teacher professional learning programs designed to enhance adolescents' health and

333 development.

334

335

344

345 *Competing Interests*

346 The authors have no competing interests to declare. No financial disclosures were reported by

347 the authors of this paper.

348

349 *Author Contributions*

350 CL and DL conceived the study and CL led its development and design. DL, AL, MK, IM, JG,

351 LP, AB, GK, AM, and NN provided input on the design the intervention. KO, RW, FM, DC,

352 DL, AL, EC and GK provided input on design of the study. EC, NN and TD designed and led

353 the data analysis. CL drafted the manuscript. All authors edited and approved the final version

354 of the paper.

355

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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)

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Note: Except where indicated, values represent sample means, with standard deviations in parentheses. BMI = body mass index (kg/m²).
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).

Supplementary File 1a. Intervention components.

Phase	Component (Duration &Setting)	Elements	Timing
Main intervention (Year 1)	Face-to-face Workshop 1 (1 day at local university)	Elements: • 2 x 30 min and 1 x 15 min presentations by members of the research team, • Individual work completed via the project website: videos of good/poor practice examples, video-based self-reflection, and action planning (i.e., goal-setting), • group discussion and opportunities for teachers to practice implementing taught principles in simulated scenarios (i.e., microteaching exercises).	Term 2
	Implementation Task 1 (30 min self-reflection, 30 min mentoring at teacher's school)	Elements: • Independent self-reflection: Using the website, teachers reflected on video recordings made by project staff. Reflections focused on implementation of teaching strategies from their Workshop 1 action plan. • Mentoring conversation to provide teachers with feedback on strategy implementation.	
	Group Mentoring Session 1 (30 mins at each school)	Led by AMPED mentor.	
	Face-to-Face Workshop 2	Similar to Workshop 1, plus physical activity feedback regarding baseline lessons.	Term 3
	Implementation Task 2	Similar to Implementation Task 1, plus physical activity feedback regarding a mid-	

		intervention lesson.	
	Group Mentoring Session 2	Similar to Group Mentoring Session 1, but led by teacher within school. AMPED mentor observed.	
Booster Intervention (Year 2)	Face-to-face Workshop 3 (1/2 day)	Review and group discussion of AMPED strategies, including facilitators and barriers in the school. Action planning by individual teachers.	Term 1
	Implementation Task 3	Online self-reflection task, based on teacher's memory of implementation. No video of teaching provided. No individual mentoring.	
	Group Mentoring Session 3	Similar to Group Mentoring Session 2, but no AMPED mentor present.	

Supplementary File 1b: AMPED Intervention Principles and Teaching Strategies

AMPED Principles	AMPED Teaching Strategies
Maximising Movement and Skill Development	1. Include an active warm-up with dynamic stretching.
	2. Provide lots of equipment.
	3. Employ circuits and rotations.
	4. Use grids effectively.
	5. Implement small sided games.
	6. Organise non-elimination games.
	7. Modify games to maximize activity and skill development.
	8. Integrate fitness into activities.
	9. Choose activities that maximize MVPA.
Reducing Transition Time	1. Manage the change room effectively.
	2. Take the roll while students are active.
	3. Early activity set-up.
	4. Distribute equipment quickly.
	5. Decrease talk/instructions.
	6. Form groups efficiently.
	7. Manage water breaks efficiently.
Building Competence	1. Provide overview of lesson/unit.
	2. Make behavioural expectations clear.
	3. Use questioning.
	4. Provide effective positive feedback.
	5. Provide effective corrective feedback.
	6. Match task to ability level.
	7. Limit peer comparison.
	8. Promote self-comparison.
Supporting Students (including support for students' autonomy and relatedness needs)	1. Emphasise fun and variety.
	2. Circulate around the class.
	3. Provide students with opportunities to make choices.
	4. Provide a rationale and emphasise relevance.
	5. Minimise controlling language and behavior.
	6. Take the students' perspective.

Supplementary Figure 1a: Screen shot of a self-reflection exercise on the AMPED website.
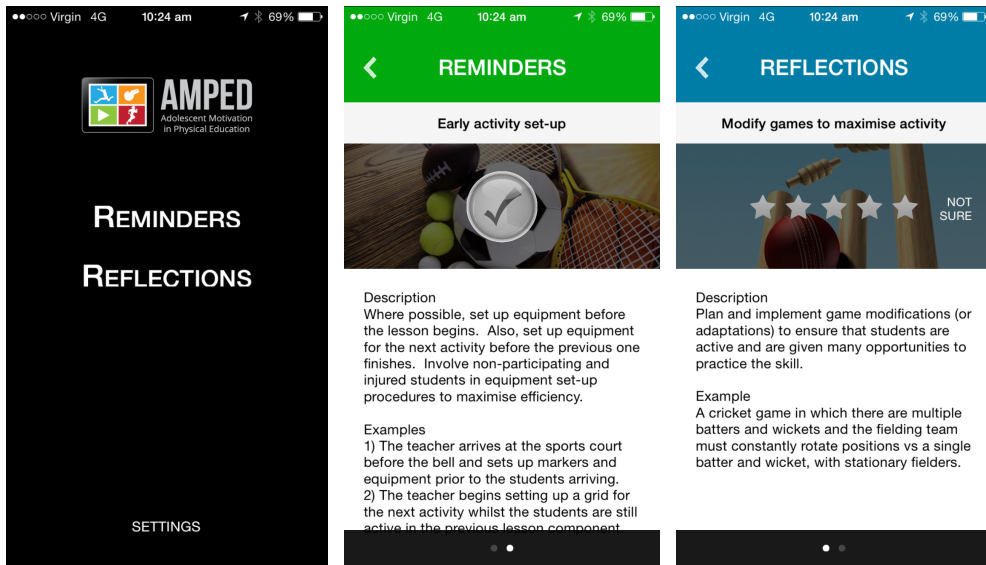
Supplementary Figure 1b: Screen shots of the AMPED mobile application.

Supplementary File 2a. Changes in teacher behaviour outcomes measures at post-intervention assessment.

Measure	Control, Mean (SD)				Intervention, Mean (SD)				Adjusted Difference in Change			Cohen's d	ICC - School
	Baseline		Post-intervention		Baseline		Post-intervention		Estimate	SE (95% CI)	p		
Maximising Movement and Skill Development	n = 32	17.50 (5.24)	n = 29	18.10 (4.44)	n = 32	18.28 (3.48)	n = 29	27.90 (6.77)	8.72	1.65 (5.50 to 11.98)	<0.001	1.96	0.23
Reducing Transition Time	n = 32	11.50 (3.64)	n = 29	10.62 (2.53)	n = 32	10.28 (1.78)	n = 29	22.03 (4.10)	12.49	0.92 (10.70 to 14.30)	<0.001	4.36	0.22
Building Competence	n = 32	18.41 (4.73)	n = 29	16.83 (2.63)	n = 32	17.31 (3.36)	n = 29	22.83 (5.30)	6.96	1.14 (4.75 to 9.19)	<0.001	1.67	0.23
Supporting Students	n = 32	13.75 (3.07)	n = 29	13.93 (3.50)	n = 32	13.72 (3.14)	n = 29	19.90 (4.23)	5.95	0.84 (4.32 to 7.59)	<0.001	1.92	0.24

Note: All mean values refer to ratings made by independent observers. Maximising Movement and Skill Development measured on scale from 9 to 45 (sum of 9 items, each with a 1 to 5 Likert scale). Reducing Transition Time measured on scale from 7 to 35. Building Competence measured on scale from 8 to 40. Supporting Students measured on scale from 6 to 30. 20% of videos were double-rated with an overall intra-class correlation of 0.67 for these ratings. Cohen's d = adjusted difference in change / pooled SD at baseline. Changes to outcomes after trial commenced – We intended to examine video-based ratings of teachers' implementation at all three time points. Due to limited resources, however, we could not employ blinded raters for final phase (i.e., maintenance). Thus, only baseline and post-intervention ratings could be analyzed.

Supplementary File 2b. Teacher Process Evaluation Ratings.

Intervention Component	Rating Mean	SD
Overall intervention		
Enjoyable	4.58	0.52
Useful	4.82	0.38
Presentations of the AMPED Principles and Strategies		
Increased my understanding	4.51	0.57
Provided me with useful strategies	4.54	0.54
Good & Poor Practice Videos – online reflection		
Useful	4.52	0.49
My Practice Videos – online self-reflection		
Useful	4.76	0.59
Group Discussion		
Increased my understanding	4.34	0.56
Micro-teaching		
Increased my understanding	4.35	0.65
Increased my confidence	4.35	0.59
Helped me implement	4.46	0.56
Action Planning		
Helped me implement	4.33	0.57
Mentoring		
Useful	4.45	0.51
Website		
System Usability Score	4.60	0.48

Note: All items rated on a scale from 1 (strongly disagree) to 5 (strongly agree).

Supplementary File 2c. AMPED Intervention Adoption.

Core Components	Proportion of Teachers Completing
Good and Poor Practice Reflection Online During Workshop	97.88%
My Practice Self-reflection Online During Workshop	98.11%
My Practice Self-reflection Homework Online	83.49%
Action Plans	95.28%
Mentor Meetings	88.68%
Additional Components	
Resources Downloaded	71.70%
Mobile App downloaded	90.57%
Used Mobile App	52.83%

Note: Adoption data collected from the website database. Changes to analyses after trial commenced – We intended to conduct per protocol analyses to investigate the influence of teachers' adoption of the intervention, as indicated by the proportion of intervention components completed by each teacher (e.g., workshops attended and online tasks completed), on student outcomes (e.g., MVPA during PE lessons). However, most teachers completed all components and these ceiling effects precluded meaningful per protocol analyses.

Supplementary File 3a. Teacher behaviour moderators of intervention effects on the proportion of time students spent in MVPA during PE lessons at post-intervention assessment

Teacher BehaviorModerator Subgroups	Intervention-Control Adjusted Difference in Change (95%CI)	p	Moderator Effect Estimate (95%CI)	p
Maximising Movement and Skill Development			0.39 (-0.06 to 0.83)	0.090
-1 *SD*	5.29 (2.36 to 8.38)	0.001		
At the Mean	3.65 (1.37 to 6.05)	0.002		
+1 *SD*	2.00 (-0.95 to 5.07)	0.192		
Reducing Transition Time			0.56 (-0.07 to 1.19)	0.085
-1 *SD*	5.34 (2.37 to 8.45)	<0.001		
At the Mean	3.66 (1.38 to 6.08)	0.002		
+1 *SD*	1.99 (-0.93 to 5.04)	0.192		
Supporting Students			1.13 (0.48 to 1.79)	0.001
-1 *SD*	6.97 (4.01 to 10.09)	<0.001		
At the Mean	3.75 (1.48 to 6.15)	0.002		
+1 *SD*	0.52 (-2.37 to 3.53)	0.728		
Building Competence			0.56 (0.10 to 1.03)	0.017
-1 *SD*	5.99 (2.98 to 9.14)	<0.001		
At the Mean	3.67 (1.39 to 6.08)	0.002		
+1 *SD*	1.36 (-1.53 to 4.37)	0.369		

Note: Teacher behaviors were not measured at the maintenance assessment.

Supplementary File 3b. Student variable moderators of intervention effects on the proportion of time students spent in MVPA during PE lessons at post-intervention assessment
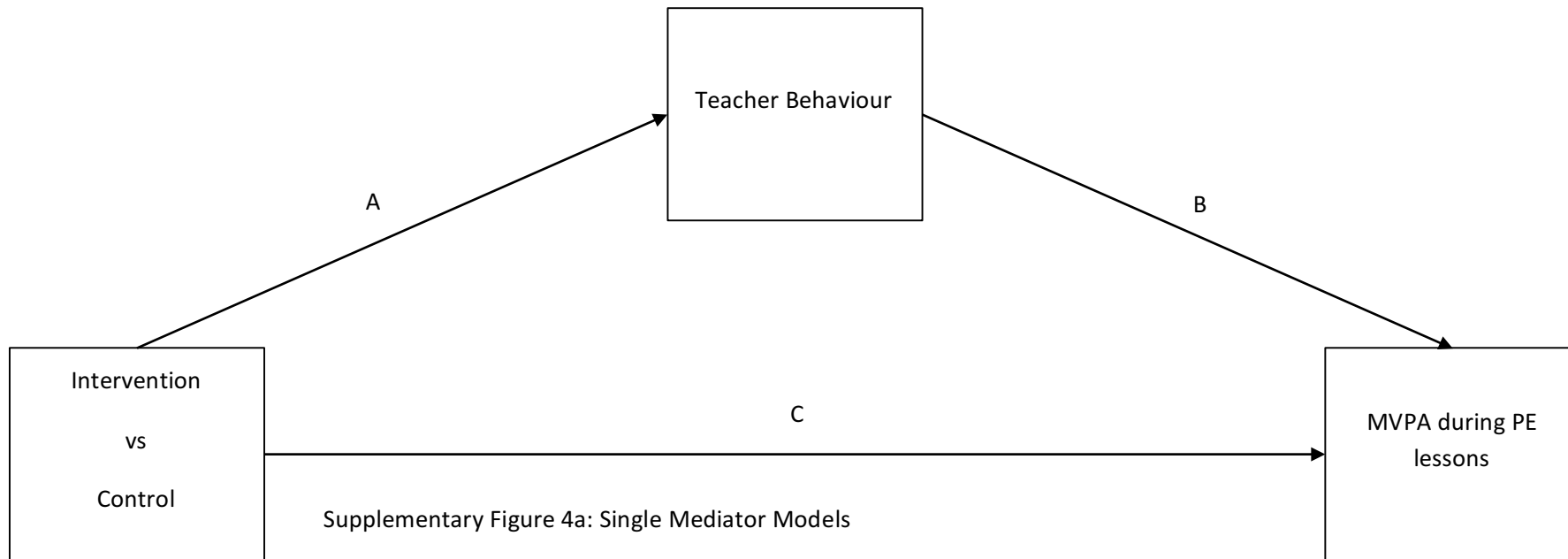
Student Variable Moderator Subgroups	Intervention-Control Adjusted Difference in Change (95%CI)	p	Moderator Estimate (95%CI)	p
Sex			-0.78 (-2.45 to 0.89)	0.361
Boys	5.30 (4.07 to 6.52)	<0.001		
Girls	6.08 (4.68 to 7.48)	<0.001		
Ethnicity			2.14 (0.13 to 4.13)[1] 2.35 (0.56 to 4.15)[2] 1.39 (-1.74 to 4.49)[3]	0.036[1] 0.010[2] 0.387[3]
English/European	5.50 (4.45 to 6.56)	<0.001		
Aboriginal/Torres Strait Islander origin	4.00 (2.23 to 5.77)	<0.001		
Others	3.76 (2.25 to 5.29)	<0.001		
SES			-0.02 (-0.23 to 0.13)	0.844
-1 SD	5.79 (4.35 to 7.25)	<0.001		
At the Mean	5.89 (4.77 to 7.01)	<0.001		
+1 SD	5.98 (4.54 to 7.42)	<0.001		
Amotivation			-1.06 (-2.03 to -0.09)	0.033
-1 SD	4.35 (3.03 to 5.67)	<0.001		
At the Mean	5.26 (4.29 to 6.24)	<0.001		
+1 SD	6.17 (4.93 to 7.42)	<0.001		
Controlled Motivation			0.03 (-1.02 to 1.09)	0.949
-1 SD	5.37 (4.09 to 6.65)	<0.001		
At the Mean	5.34 (4.37 to 6.32)	<0.001		
+1 SD	5.32 (4.05 to 6.58)	<0.001		
Autonomous Motivation			1.27 (0.24 to 2.31)	0.016
-1 SD	6.36 (5.13 to 7.61)	<0.001		
At the Mean	5.31 (4.34 to 6.29)	<0.001		
+1 SD	4.25 (2.90 to 5.61)	<0.001		
Autonomy Need Satisfaction			0.33 (-0.31 to 0.96)	0.310
-1 SD	5.74 (4.52 to 6.96)	<0.001		
At the Mean	5.30 (4.32 to 6.30)	<0.001		
+1 SD	4.88 (3.53 to 6.24)	<0.001		
Competence Need Satisfaction			0.29 (-0.29 to 0.86)	0.331
-1 SD	5.77 (4.53 to 7.01)	<0.001		
At the Mean	5.35 (4.38 to 6.33)	<0.001		
+1 SD	4.94 (3.61 to 6.27)	<0.001		
Relatedness Need Satisfaction			0.53 (-0.03 to 1.10)	0.063
-1 SD	6.06 (4.82 to 7.30)	<0.001		
At the Mean	5.27 (4.29 to 6.25)	<0.001		
+1 SD	4.47 (3.15 to 5.80)	<0.001		
Baseline MVPA during PE Lessons			0.20 (0.09 to 0.32)	0.001
-1 SD	6.94 (5.73 to 8.16)	<0.001		
At the Mean	5.57 (4.68 to 6.47)	<0.001		
+1 SD	4.20 (3.03 to 5.38)	<0.001		

Note: [1] English/European versus Aboriginal/Torres Strait Islander. [2] English/European versus Others. [3] Aboriginal/Torres Strait Islander versus Others.

Supplementary File 3c. Student variable moderators of intervention effects on the proportion of time students spent in MVPA during PE lessons at maintenance assessment

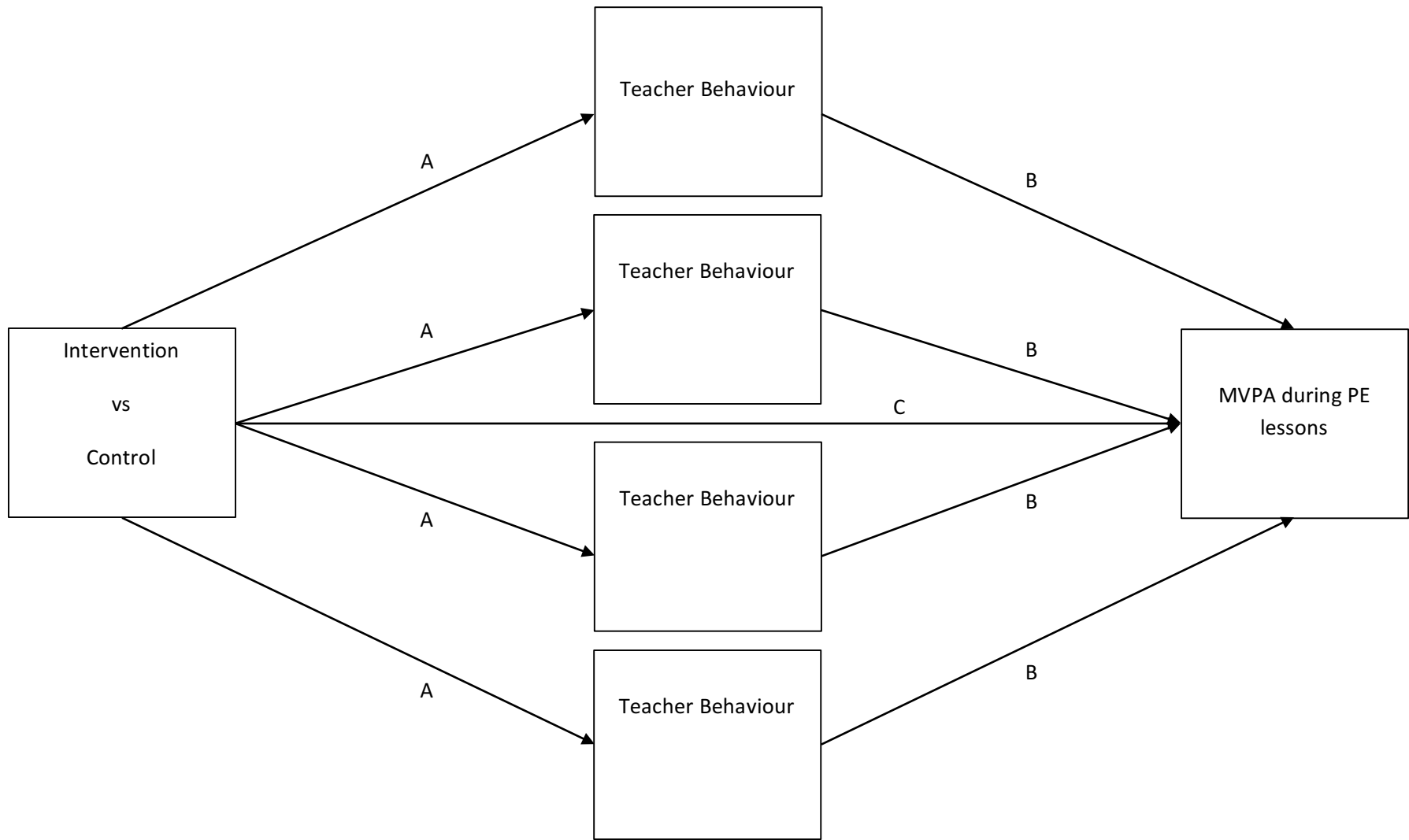| Student Variable Moderator Subgroups	Intervention-Control Adjusted Difference in Change (95%CI)	p	Moderator Estimate (95%CI)	p
Sex			-1.33 (-2.34 to -0.32)	0.001
Boys	1.94 (0.51 to 3.40)	0.01		
Girls	3.28 (1.79 to 4.76)	<0.001		
Ethnicity			2.03 (-4.58 to 0.54)[1] 0.38 (-0.65 to 1.41)[2] -0.22 (-1.65 to 2.10)[3]	0.122[1] 0.466[2] 0.820[3]
English/European	2.62 (1.15 to 4.10)	0.001		
Aboriginal/Torres Strait Islander origin	2.10 (0.46 to 3.78)	0.014		
Others	2.32 (0.73 to 3.93)	0.005		
SES			0.03 (-0.05 to 0.12)	0.462
-1 SD	2.89 (1.33 to 4.43)	<0.001		
At the Mean	2.70 (1.24 to 4.14)	<0.001		
+1 SD	2.50 (0.97 to 4.03)	0.002		
Amotivation			-0.43 (-0.99 to 0.13)	0.130
-1 SD	2.22 (0.69 to 3.77)	0.003		
At the Mean	2.59 (1.13 to 4.06)	<0.001		
+1 SD	2.96 (1.43 to 4.49)	<0.001		
Controlled Motivation			0.38 (-0.21 to 0.97)	0.207
-1 SD	2.88 (1.37 to 4.42)	<0.001		
At the Mean	2.59 (1.13 to 4.06)	0.001		
+1 SD	2.29 (0.77 to 3.84)	0.004		
Autonomous Motivation			0.26 (-0.31 to 0.83)	0.375
-1 SD	2.87 (1.35 to 4.40)	<0.001		
At the Mean	2.65 (1.20 to 4.12)	0.001		
+1 SD	2.44 (0.91 to 3.99)	0.002		
Autonomy Need Satisfaction			0.05 (-0.30 to 0.40)	0.798
-1 SD	2.84 (1.33 to 4.38)	<0.001		
At the Mean	2.78 (1.33 to 4.26)	<0.001		
+1 SD	2.72 (1.20 to 4.28)	0.001		
CompetenceNeed Satisfaction			-0.06 (-0.39 to 0.26)	0.708
-1 SD	2.78 (1.27 to 4.32)	<0.001		
At the Mean	2.87 (1.43 to 4.34)	<0.001		
+1 SD	2.96 (1.44to 4.51)	<0.001		
RelatednessNeed Satisfaction			0.11 (-0.20 to 0.42)	0.497
-1 SD	2.90 (1.39 to 4.44)	<0.001		
At the Mean	2.74 (1.29 to 4.21)	<0.001		
+1 SD	2.58 (1.06 to 4.13)	0.001		
Baseline MVPA during PE Lessons			0.14 (0.07to 0.20)	<0.001
-1 SD	3.74 (2.43to 5.06)	<0.001		
At the Mean	2.82 (1.59 to 4.06)	<0.001		
+1 SD	1.91 (0.07 to 0.20)	0.004		

Note:[1] English/European versus Aboriginal/Torres Strait Islander. [2] English/European versus Others. [3] Aboriginal/Torres Strait Islander versus Others.

Supplementary Figure 4a: Single Mediator Models

Supplementary Figure 4b: Multiple Mediator Model

Supplementary File 4a. Teacher behaviours - single mediator models testing the effect of the intervention on the proportion of time students spent in MVPA during PE lessons at maintenance assessment

Teacher behaviour mediators	Action theory test			Conceptual theory test			Direct effect			Significance of mediated effect			Absolute value Proportion (%)
	A	95% CI	P value	B	95% CI	P value	C	95% CI	P value	A*B	95% CI	P value	|AB|/(|AB|+|C|)
Maximising Movement and Skill Development	10.94	5.25 to 16.63	0.000	0.45	0.25 to 0.66	<0.001	1.07	-2.32 to 4.46	0.535	4.97	0.69 to 9.25	0.023	82.28
Reducing Transition Time	12.66	10.82 to 14.51	0.000	0.48	0.14 to 0.82	0.006	-0.11	-3.23 to 3.01	0.945	6.05	1.58 to 10.53	0.008	98.21
Building Competence	7.35	3.51 to 11.19	0.000	0.31	-0.00 to 0.62	0.051	3.84	0.59 to 7.09	0.020	2.27	-0.42 to 4.96	0.098	37.15
Supporting Students	7.05	4.77 to 9.33	0.000	0.63	0.15 to 1.12	0.011	1.61	-1.32 to 4.54	0.283	4.46	0.39 to 8.54	0.032	73.48

Note: Mediating effects using a cluster-bootstrapped based product-of-coefficients test (47). A = unstandardised regression coefficient of treatment condition predicting change in the hypothesised mediator; B = unstandardised regression coefficient of change in hypothesised mediator predicting change in physical activity behaviour; C = unstandardised regression coefficient of the intervention predicting physical activity behaviour accounting for effect of the mediator; AB, product of coefficients estimate.

Supplementary File 4b. Teacher behaviours – multiple mediator model testing the effect of the intervention on the proportion of time students spent in MVPA during PE lessons at maintenance assessment

Teacher behaviour mediators	Action theory test			Conceptual theory test			Direct effect			Significance of mediated effect			Absolute value Proportion (%)
	A	95% CI	P value	B	95% CI	P value	C	95% CI	P value	A*B	95% CI	P value	|AB|/(|AB|+|C|)
							-0.06	-0.19 to 0.06	0.320				
Maximising Movement and Skill Development	10.90	10.18 to 11.61	0.000	0.36	0.22 to 0.50	<0.001				3.91	2.31 to 5.51	<0.001	98.49
Reducing Transition Time	12.50	12.11 to 12.89	0.000	0.19	-0.07 to 0.44	0.147				2.32	-0.82 to 5.48	0.147	97.48
Building Competence	7.35	6.87 to 7.83	0.000	-0.20	-0.48 to 0.08	0.167				-1.47	-3.55 to 0.62	0.168	96.08
Supporting Students	7.01	6.63 to 7.38	0.000	0.38	-0.04 to 0.80	0.077				2.67	-0.29 to 5.62	0.077	97.80

Note: A = unstandardised regression coefficient of treatment condition predicting change in hypothesised mediators; B = unstandardised regression coefficient of change in hypothesised mediators predicting change in physical activity behaviour; C = unstandardised regression coefficient of the intervention predicting physical activity behaviour accounting for effect of the mediator; AB, product of coefficients estimate.

Supplementary File 5a – Intervention effects on student participation rates in PE lessons at post-intervention.

Denominator	Control, Mean (SD)				*p*	Intervention, Mean (SD)				*p*	Adjusted Difference in Change		*p*	Cohen's d	ICC	
	Baseline		F1			Baseline		F1			Estimate	SE (95% CI)			Teacher	School
Students attending	n = 39	0.92 (0.19)	n = 39	0.93 (0.11)	0.914	n = 35	0.93 (0.11)	n = 35	0.91 (0.12)	0.450	-0.02	0.04 (-0.10 to 0.05)	0.614	0.17	0.22	-
Students enrolled	n = 35	0.78 (0.21)	n = 37	0.72 (0.14)	0.075	n = 34	0.74 (0.12)	n = 34	0.70 (0.14)	0.100	0.02	0.04 (-0.06 to 0.11)	0.547	0.14	0.31	-

Note: Values represent the proportion of students participating in a lesson. The numerator is the number of students participating in the lesson. n = classes from which data was collected.

Supplementary File 5b – Intervention effects on student participation rates in PE lessons at maintenance.

Denominator	Control, Mean (SD)				*p*	Intervention, Mean (SD)				*p*	Adjusted Difference in Change		*p*	Cohen's d	ICC	
	Baseline		F2			Baseline		F2			Estimate	SE (95% CI)			Teacher	School
Students attending	n = 39	0.92 (0.19)	n = 37	0.94 (0.17)	0.711	n = 35	0.93 (0.11)	n = 34	0.92 (0.12)	0.855	-0.01	0.02 (-0.01 to 0.03)	0.675	0.14	0.21	-
Students enrolled	n = 35	0.78 (0.21)	n = 36	0.74 (0.23)	0.003	n = 34	0.74 (0.12)	n = 32	0.68 (0.15)	<0.001	0.01	0.03 (-0.05 to 0.07)	0.618	0.31	0.13	-

Note: Values represent the proportion of students participating in a lesson. The numerator is the number of students participating in the lesson. n = classes from which data was collected.

Supplementary File 6a. Intervention effects on motivational mediators at post-intervention assessment.

Variable	Control, Mean (SD) Baseline		Control, Mean (SD) Post-intervention		p	Intervention, Mean (SD) Baseline		Intervention, Mean (SD) Post-intervention		p	Intervention – Control Adjusted Difference in Change Estimate	95% CI	p	Cohen's d	ICC Student	Class	Teacher	School
Motivation and Needs Satisfaction in PE																		
Amotivation	n = 738	2.09 (0.88)	n = 630	2.05 (0.87)	0.096	n = 706	2.0 (0.84)	n = 625	1.92 (0.80)	0.026	0.06	-0.03 to 0.14	0.188	0.06	0.46	0.02	0.01	0.01
Autonomous Motivation	n = 738	3.97 (0.87)	n = 630	3.80 (0.86)	<0.001	n = 706	4.03 (0.80)	n = 624	3.89 (0.82)	<0.001	-0.03	-0.10 to 0.04	0.375	-0.03	0.53	0.04	0.00	-
Controlled Motivation	n = 738	2.85 (0.76)	n = 629	2.70 (0.73)	<0.001	n = 706	2.89 (0.80)	n = 625	2.73 (0.78)	<0.001	-0.01	-0.1 to 0.09	0.877	-0.01	0.44	0.02	0.02	-
Autonomy Need Satisfaction	n = 723	3.51 (1.32)	n = 610	3.50 (1.34)	0.492	n = 697	3.44 (1.29)	n = 617	3.48 (1.20)	0.566	0.02	-0.14 to 0.18	0.805	0.01	0.37	0.04	0.00	0.02
Competence Need Satisfaction	n = 723	4.54 (1.51)	n = 610	4.38 (1.50)	0.007	n = 697	4.57 (1.41)	n = 617	4.37 (1.42)	<0.001	-0.03	-0.17 to 0.13	0.729	-0.02	0.56	0.02	0.01	0.03
Relatedness Need Satisfaction	n = 723	4.19 (1.50)	n = 610	4.05 (1.47)	0.179	n = 697	4.37 (1.46)	n = 617	4.22 (1.34)	0.012	-0.05	-0.23 to 0.13	0.556	-0.03	0.44	0.03	0.01	-
Student Perceptions of PE Teacher Behavior																		
Controlling behavior	n = 719	2.85 (1.33)	n = 616	2.70 (0.73)	0.809	n = 693	2.65 (1.36)	n = 607	2.72 (0.78)	0.638	-0.03	-0.23 to 0.13	0.743	-0.02	0.33	0.06	0.01	-
Supportive behavior	n = 726	4.31 (1.31)	n = 631	4.37 (1.32)	0.340	n = 698	4.53 (1.27)	n = 616	4.60 (1.17)	0.204	0.03	-0.12 to 0.17	0.688	0.02	0.45	0.06	0.01	-
Motivation towards Leisure-time Physical Activity																		
Amotivation	n = 728	1.68 (0.86)	n = 624	1.67 (0.82)	0.732	n = 704	1.65 (0.82)	n = 621	1.59 (0.76)	0.164	-0.03	-0.15 to 0.07	0.522	-0.03	0.44	0.01	0.01	-
Autonomous Motivation	n = 729	3.55 (0.88)	n = 624	3.43 (0.88)	0.003	n = 704	3.50 (0.85)	n = 621	3.41 (0.88)	0.028	0.03	-0.06 to 0.13	0.497	0.03	0.52	0.02	0.00	-
Controlled Motivation	n = 729	2.40 (0.85)	n = 624	2.24 (0.80)	<0.001	n = 704	2.32 (0.86)	n = 621	2.30 (0.84)	0.794	0.15	0.04 to 0.25	0.005	0.18	0.47	0.01	0.02	0.01

Note: *Note*: Motivation variables and leisure-time physical activity frequency measured on scales from 1 to 5. Student need satisfaction and perceptions of teacher behaviour measured on scales from 1 to 7. Leisure-time physical activity duration measured on a scale from 1 to 8. 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.

Supplementary File 6b. Intervention effects on well-being outcomes and motivational mediators at maintenance assessment.

Variable	Control, Mean (SD) Baseline	Maintenance	p	Intervention, Mean (SD) Baseline	Maintenance	p	Intervention – Control Adjusted Difference in Change Estimate	95% CI	p	Cohen's d	ICC ID	Class	Teacher	School
Motivation and Needs Satisfaction in PE														
Amotivation	n = 738 2.09 (0.88)	n = 525 2.10 (0.91)	0.239	n = 706 2.00 (0.84)	n = 507 2.02 (0.80)	0.471	0.05	-0.02 to 0.13	0.185	0.05	0.46	0.02	0.00	0.01
Autonomous Motivation	n = 738 3.97 (0.86)	n = 525 3.74 (0.87)	0.013	n = 706 4.03 (0.80)	n = 507 3.82 (0.83)	<0.001	0.01	-0.08 to 0.11	0.767	0.01	0.54	0.03	0.02	-
Controlled Motivation	n = 738 2.84 (0.76)	n = 525 2.70 (0.70)	0.001	n = 706 2.88 (0.80)	n = 507 2.79 (0.76)	0.182	0.06	-0.02 to 0.14	0.149	0.07	0.42	0.03	0.02	-
Autonomy Need Satisfaction	n = 723 3.51 (1.32)	n = 496 3.51 (1.35)	0.292	n = 697 3.45 (1.35)	n = 493 3.65 (1.26)	0.014	0.07	-0.06 to 0.21	0.333	0.05	0.30	0.04	0.00	0.04
Competence Need Satisfaction	n = 723 4.54 (1.51)	n = 496 4.44 (1.47)	0.911	n = 697 4.57 (1.41)	n = 493 4.48 (1.36)	0.280	-0.04	-0.18 to 0.09	0.574	-0.03	0.55	0.03	0.00	0.03
Relatedness Need Satisfaction	n = 723 4.19 (1.50)	n = 496 4.16 (1.49)	0.498	n = 697 4.37 (1.46)	n = 493 4.37 (1.33)	0.636	-0.05	-0.2 to 0.11	0.473	-0.03	0.39	0.03	0.00	0.02
Student Perceptions of PE Teacher Behavior														
Controlling behavior	n = 719 2.85 (1.34)	n = 511 2.70 (0.71)	0.520	n = 693 2.65 (1.36)	n = 512 2.79 (0.76)	0.010	0.12	-0.06 to 0.29	0.181	0.09	0.27	0.07	0.01	-
Supportive behavior	n = 726 4.31 (1.31)	n = 518 4.47 (1.38)	0.080	n = 698 4.53 (1.27)	n = 512 4.47 (1.26)	0.397	-0.16	-0.32 to 0.01	0.059	-0.12	0.43	0.09	0.00	0.03
Motivation towards Leisure-time Physical Activity														
Amotivation	n = 728 1.68 (0.86)	n = 503 1.75 (0.88)	0.304	n = 704 1.65 (0.82)	n = 501 1.65 (0.76)	0.496	-0.05	-0.14 to 0.04	0.210	-0.03	0.41	0.03	0.00	-
Autonomous Motivation	n = 729 3.55 (0.88)	n = 503 3.42 (0.92)	0.027	n = 704 3.50 (0.85)	n = 501 3.43 (0.92)	0.800	0.06	-0.01 to 0.13	0.094	0.03	0.53	0.01	0.00	-
Controlled Motivation	n = 729 2.40 (0.85)	n = 503 2.33 (0.90)	0.235	n = 704 2.32 (0.86)	n = 501 2.35 (0.86)	0.813	0.04	-0.03 to 0.13	0.269	0.15	0.45	0.00	0.02	-

Note: Motivation variables and leisure-time physical activity frequency measured on scales from 1 to 5. Student need satisfaction and perceptions of teacher behaviour measured on scales from 1 to 7. Leisure-time physical activity duration measured on a scale from 1 to 8. 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.