The Physical Activity 4 Everyone Cluster Randomized Trial

2-Year Outcomes of a School Physical Activity Intervention Among Adolescents

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Introduction: Few interventions have been successful in reducing the physical activity decline typically observed among adolescents. The aim of this paper is to report the 24-month effectiveness of a multicomponent school-based intervention (Physical Activity 4 Everyone) in reducing the decline in moderate to vigorous physical activity (MVPA) among secondary school students in disadvantaged areas of New South Wales, Australia.

Study design: A cluster RCT was conducted in five intervention and five control schools with follow-up measures taken at 24 months post-randomization.

Setting/participants: The trial was undertaken within secondary schools located in disadvantaged communities in New South Wales, Australia.

Intervention: A multicomponent school-based intervention based on the Health Promoting Schools Framework was implemented. The intervention consisted of seven physical activity promotion strategies that targeted the curriculum (teaching strategies to increase physical activity in physical education lessons, student physical activity plans, and modification of school sport program); school environment (recess/lunchtime activities, school physical activity policy); parents (parent newsletters); and community (community physical activity provider promotion). Six additional strategies supported school implementation of the physical activity intervention strategies.

Main outcome measure: Minutes per day spent in MVPA, objectively measured by accelerometer.

Results: Participants (N=1,150, 49% male) were a cohort of students aged 12 years (Grade 7) at baseline (March–June 2012) and 14 years (Grade 9) at follow-up (March–July 2014). At 24-month follow-up, there were significant effects in favor of the intervention group for daily minutes of MVPA. The adjusted mean difference in change in daily MVPA between groups was 7.0 minutes (95% CI=2.7, 11.4, $p<0.002$) (analysis conducted December 2014–February 2015). Sensitivity analyses based on multiple imputation were consistent with the main analysis (6.0 minutes, 95% CI=0.6, 11.3, $p<0.031$).

Conclusions: The intervention was effective in increasing adolescents' minutes of MVPA, suggesting that implementation of the intervention by disadvantaged schools has the potential to slow the decline in physical activity.

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Introduction

Adequate physical activity reduces the risk of a range of non-communicable diseases.[1,2] Despite this, only 20% of adolescents accumulate the necessary amount to meet the recommended 60 minutes of moderate to vigorous physical activity (MVPA) per day.[2] Physical activity declines by 7% per year during adolescence,[3] and the decline is higher among those from disadvantaged backgrounds.[4] However, few interventions have targeted this high-risk group.[5,6]

Comprehensive school-based physical activity interventions have been endorsed by health and education authorities as a strategy for promoting physical activity.[7–10] Systematic reviews of studies in schools indicate that physical activity interventions are effective in increasing the proportion of students meeting physical activity guidelines,[11] physical activity duration,[5,11,12] and improving fitness and fundamental movement skills.[11–14]

In the most recent Cochrane systematic review of school-based physical activity interventions,[11] only 14 of 44 targeted secondary schools. Two of these targeted schools in lower-SES areas,[15,16] with one showing an intervention effect.[15] A further three trials published since targeted either low-SES girls only[17,18] or low-SES boys only.[19] However, none resulted in significant intervention effects for physical activity.[12]

Given the limited evidence, a trial was undertaken to determine whether a multicomponent physical activity intervention implemented in secondary schools in disadvantaged communities (Physical Activity 4 Everyone [PA4E1]) was effective in reducing the decline in MVPA among students. As previously reported, mid-intervention results were promising, with significant effects in favor of the intervention group for daily minutes of MVPA (adjusted mean difference in change between groups, 3.9 minutes, 95% CI=0.79, 6.91, $p<0.01$).[20] This paper reports the 24-month effectiveness of the PA4E1 intervention in reducing the decline in MVPA among secondary school students in disadvantaged areas. The secondary aim is to explore the impact of the intervention on five additional MVPA-based measures.

Methods

Study Design, Setting, and Participants

A cluster RCT was conducted with secondary schools (five intervention, five control) in disadvantaged communities. Outcome assessments were conducted with a cohort of students at baseline (Grade 7); 12 months (mid-intervention); and 24 months post-randomization follow-up. The primary outcome was objectively measured daily minutes of MVPA. Details of the study methods have been reported.[21] The trial was registered with the Australian New Zealand Clinical Trials Registry (ACTRN1261200038287) and approved by the Hunter New England Area Human Research Ethics Committee (11/03/16/4.0) and the University of Newcastle Human Research Ethics Committee (H-2011-0210). The study adheres to the CONSORT and extension for cluster trials guidelines (www.consort-statement.org).

Schools were considered eligible for inclusion if they met the following criteria: Government or Catholic schools; had a SES score of ≤5 (lower 50% of New South Wales) based on postcode[22]; had at least 120 Grade 7 students; and were not participating in other physical activity intervention studies. Recruitment and consent of schools occurred from October to December 2011, via face-to-face meetings with the school principal. Opt-in parental consent was required. A list of eligible schools was created from which schools were randomly selected until ten consented to participate.

A cohort of all students in their first year of high school (Grade 7) were invited to participate in the study via consent forms sent to parents. Students with severe mental or physical disabilities were excluded. Where signed parental and student consent forms were not received by the required date, parents were contacted via telephone by school-affiliated staff and asked for consent and to provide a signed consent form.

Physical education (PE) teachers in intervention schools were invited to participate in a survey at 24-month follow-up.

Random allocation of schools (cluster) to the intervention or control group was undertaken following baseline data collection by an independent statistician, using block randomization (1:1 ratio), based on a random number function.

Intervention

The intervention was guided by social cognitive[23] and social-ecologic theories[24] and utilized the WHO's Health Promoting Schools framework. The framework recommends strategies addressing the school curriculum, school environment, and partnerships and services.[25–29]

The intervention was delivered over seven to eight school terms (average, 24 months) and involved implementation of seven physical activity intervention strategies and six strategies to support implementation of the intervention (Appendix Figure 1, available online). The physical activity strategies were implemented progressively over the 24-month intervention period, with Strategies 3, 4, and 7 implemented in the final 12 months and the remaining strategies (1, 2, 5, and 6) throughout the whole intervention period. The six intervention implementation strategies were delivered throughout the intervention period (Appendix Figure 1, available online).

The physical activity intervention strategies consisted of the following strategies across the school curriculum, school environment, and partnerships and services:

1. Teaching strategies to maximize students' physical activity in health and PE lessons: PE teachers received training and resources to assist in maximizing MVPA during class time, including the use of pedometer-based lessons (two per term).[15,30,31]
2. Development and monitoring of student physical activity plans within PE lessons: Students developed individual physical activity plans that set goals and actions and recorded progress against timelines, fitness assessments, and provision of rewards.[32] Plans were to be reviewed and modified each term.[7]
3. Enhanced school sport program: All students participated in a 10-week program during school sport in Grade 8. The program, based on the effective Program X,[15] included lessons and fitness activities focused on lifelong physical activity skills and knowledge.[29,33]
4. Development/modification of school policies[34]: School policies that aimed to enhance student physical activity were reviewed by the head PE teacher and in-school consultant with input from school executive.[35]
5. Physical activity programs during school breaks: Schools were provided with physical activity equipment (e.g., balls, skipping equipment), and encouraged to offer supervised physical activity at recess and lunch on at least 2 days per week.[36]
6. Promotion of community physical activity providers (community links)[34,37]: Schools were supported to host a physical activity expo that promoted local physical activity providers to students in Grade 8.
7. Parent engagement[33,38] information was sent to parents each term via newsletters and school website promoting physical activity and local providers.

In addition to the physical activity strategies, six intervention implementation strategies were based on evidence regarding their ability to facilitate the implementation of school-based interventions, change professional service delivery practices, or build capacity of organizations.[12,39–45]

1. In-school physical activity consultant (change agent): A trained PE teacher was placed within each school for 1 day per week over the intervention period to support intervention implementation.[37]
2. Establishing leadership and support: A school committee was established, or responsibility was added to an existing committee, to lead and oversee the intervention.
3. Teacher training: PE teachers were offered three practice learning workshops focused on delivery of lessons to increase students' MVPA. All PE teachers and teachers involved in the delivery of the enhanced school sports program were provided training.[15,41,46,47]
4. Resources: Schools were provided with a manual outlining all physical activity intervention strategies and associated materials; physical activity equipment (e.g., pedometers, resistance devices); and promotional materials for teachers (e.g., shirts/lanyards) and students (e.g., balls, water bottles).
5. Prompts: The in-school consultant provided prompts to teaching staff to implement the intervention strategies via e-mail, electronic calendar reminders, and in meetings.
6. Intervention implementation performance feedback: Records kept by the in-school consultant were the basis of quarterly intervention implementation feedback reports. The results of observational audits of ten randomly selected PE lessons undertaken using the System for Observing Fitness Instruction Time were also provided on two occasions.

Schools allocated to the control group participated in the measurement components of the trial only and delivered physical activity teaching and promotion practices according to the PE curriculum and school-based initiatives.

Data Collection

Data were collected by trained research assistants blind to group allocation. Baseline data were collected in March–June 2012, and follow-up data collected after 12 months and again at 24 months (March–June 2014).

At baseline and 24-month follow-up, students wore an accelerometer (Actigraph GT3X+ and GT3X models) for 7 days during waking hours. Student characteristics were collected at baseline via an online survey.

The in-school consultant recorded delivery of all strategies. In addition, PE teachers and students in each intervention school completed a survey at 24-month follow-up that included items on intervention delivery and acceptability/perceived usefulness.

Measures

Accelerometer data were used to derive the primary physical activity outcome measure, mean student duration (minutes) of MVPA per day.

Secondary outcomes were minutes of vigorous physical activity (VPA) per day; minutes of moderate physical activity (MPA) per day; percentage of accelerometer wear time in MVPA per day; percentage of accelerometer wear time in VPA per day; percentage of accelerometer wear time in MPA per day; and mean daily accelerometer counts.

For all physical activity outcome measures, accelerometer nonwear time was defined as 30 minutes of consecutive zeroes.[48] Counts were collected in 15-second epochs and counts per minute calculated by dividing the total accelerometer counts by the minutes of wear time. The Evenson cut-points were used to categorize the intensity of physical activity (MPA or VPA).[49,50] The online survey assessed student sociodemographic characteristics: age; sex; Aboriginal or Torres Strait Islander (or both) status; and residential postcode.

Anthropometric data (height and weight) were collected in duplicate by trained research assistants using the International Society for Advanced Kinanthropometry procedures.[51] Students completed the measurements in light clothing without shoes. Weight was measured to the nearest 0.1 kg on a portable digital scale (Model no. UC-321PC, A&D Company Ltd, Tokyo Japan). Height was measured to the nearest 0.1 cm using a portable stadiometer (Model no. PE087, Mentone Educational Centre, Australia). BMI was calculated (weight in kg/[height in meters]^2) and weight status determined using the International Obesity Taskforce definitions.[52,53]

The in-school consultant records were used to determine the extent to which physical activity intervention and implementation strategies were delivered to the desired standard (Appendix Figure 1, available online). The 24-month follow-up PE teacher survey assessed the delivery of the PE curriculum strategies (Strategies 1 and 2 in Appendix Figure 1, available online). The intervention group student online survey at 24 months assessed the reach of some physical activity intervention strategies (1, 2, and 4 in Appendix Figure 1, available online).

Sample Size

It was estimated that each school would yield at least 60 students at baseline, providing approximately 300 students per group.[54,55] This assumed at least 120 Grade 7 students per school and 50% of them consenting and providing 3 days of valid accelerometer data[56] (analyses eligibility inclusion criterion). If 65% of the cohort provided usable data at 24 months, it was estimated that there would be at least 195 students per group.[57] Previous studies were used to estimate the SD of mean daily minutes of MVPA (17.1)[58] and the intraclass correlation coefficient (0.01).[59] After adjustment for a design effect of 1.38, the effective sample size was estimated to be 141 students per group. Based on ten schools, with this sample size, 80% power, and an α-level of 0.05, the study was able to detect a difference in the primary trial outcome, mean daily minutes of MVPA, between experimental and control students of ±5.73 minutes at 24-month follow-up.

Statistical Analysis

All analyses were conducted using SAS, version 9.2, from December 2014 to February 2015. Summary statistics were used to describe all variables of interest. Logistic regressions with generalized estimating equation parameter estimation were used to determine if students who provided accelerometer data at both baseline and 24 months differed from those who provided only baseline accelerometer data in terms of sex; baseline age; weight status (underweight/healthy weight versus overweight and obese); and physical activity level (meeting physical activity guidelines versus not meeting physical activity guidelines). Significance levels for such analyses were set at $p<0.05$.

Student data were included in the analyses if the accelerometer was worn for ≥600 minutes per day on any 3 days or more.[60–62] Analysis followed intention-to-treat principles. Analysis of the primary outcome measure (minutes of MVPA per day) and other physical activity outcomes was undertaken using a linear mixed model (LMM) approach. A three-level hierarchical model was used to capture correlations in the data with random intercepts for repeated measures (Level 1, mean minutes of MVPA per day at baseline, mid-point, and follow-up) on individuals (Level 2) and clustering within schools (Level 3, ten clusters, five intervention and five control). An independence structure was assumed for the residual variance–covariance matrix. Fixed effects in the model included treatment group (intervention versus control); time (baseline versus 24 months); and the interaction between treatment group and time. The containment method was used for degrees of freedom estimation. The LMM analyses sought to determine whether there was a difference in mean change from baseline to 24 months between groups in each outcome measure, assessed through an interaction term between groups.

Physical activity outcome data were analyzed assuming data were "missing at random." Sensitivity analyses were undertaken for the primary outcome, initially adjusting for any variables on which students with and without 24-month follow-up accelerometer data were significantly different, and secondly, using multiple imputation.[63] Five imputed data sets were created using a two-step multiple imputation process: First, missing data were filled in to a monotone pattern using the Markov-chain Monte Carlo method; then, the remaining missing data were filled in using the regression method (where regression equations are used to predict the missing outcome values, using baseline values of the outcomes and baseline demographic variables). The five complete data sets were then analyzed using LMM per the primary analyses, and the estimates were combined using Rubin's method.

Descriptive statistics were used to describe the proportion of students in each group meeting the Australian Physical Activity guidelines for children and young people[64] of 60 minutes of MVPA per day.

Analyses assessed whether the intervention similarly affected the primary outcome measure (mean minutes of MVPA per day) and two secondary physical activity outcome measures (mean minutes of VPA per day and mean minutes of MPA per day) for students defined, a priori, in terms of three moderators of energy balance: sex, baseline BMI, and baseline physical activity level.[65] Students were categorized into two groups for baseline BMI ("underweight/healthy weight," "overweight/obese") based on Cole cut-points.[66] Students were categorized into two groups for baseline physical activity (≥60 minutes of MVPA per day, <60 minutes of MVPA per day). The moderator variable interaction terms were included separately in the aforementioned LMM analyses for the relevant duration outcomes and, if the three-way interaction term (group X time X moderator) was significant at $p<0.20$, separate LMM analyses for the moderator subgroups were undertaken for these variables.[67]

Descriptive statistics were used to summarize in-school consultant record data regarding intervention strategy implementation, and intervention group PE teacher and student survey responses.

Results

Of 22 eligible schools, 13 were approached, 10 of which consented to participate (77%). Parental consent was obtained for 1,233 of the 1,468 Grade 7 students in the ten schools (84%) (Figure 1).

At baseline, 1,150 students wore an accelerometer, 84% of whom provided at least 3 days of valid accelerometer data (965/1,150). The 1,150 students represented 93% of students with parental consent. At 24 months, 985 students wore an accelerometer and provided anthropometric measures, and 441 (45%) of these provided at least 3 days of valid accelerometer data. The 441 students represented 36% of those with parental consent. Baseline characteristics of the 1,150 students who wore an accelerometer are shown in Table 1.

Age was the only characteristic associated with whether students provided accelerometer data at baseline only, or at both baseline and 24 months. Students who provided data only at baseline were younger than those providing data at both time points.

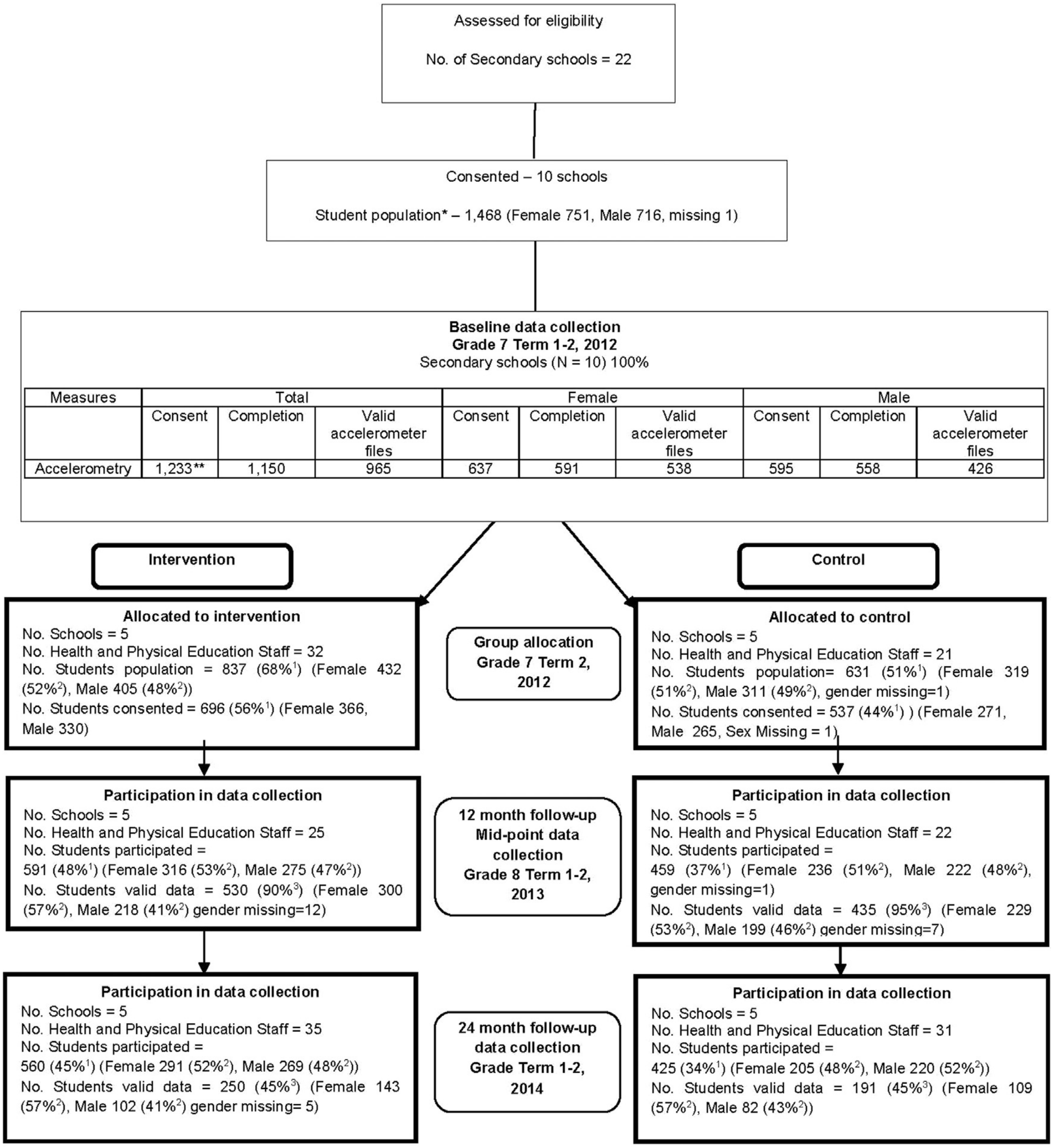

Figure 1. CONSORT flowchart describing progress of participants through the study.

*Student population excludes individuals with severe mental or physical disabilities (there were no classes for such students in the participating schools) and those on long-term suspension.

**The figure 1,233 is for parental consent to accelerometry. A slightly larger sample (1,246) had parental consent for any study measure (including anthropometry, survey).

[1]Denominator is number of students with parental consent for accelerometry at baseline 1,233.

[2]Male or female break down at the respective time point.

[3]Denominator is number of students that participated in data collection at the respective time point.

At 24 months, 35 (100%) intervention PE teachers completed the teacher survey. Students in intervention schools who completed surveys at both baseline and 24 months (n=409) were included in analysis of data on reach and acceptability of the physical activity intervention strategies.

The adjusted mean difference in change in daily MVPA between groups was 7.0 minutes (95% CI=2.7, 11.4, $p<0.002$) (Table 2). The mean duration of daily MVPA increased by 4.4 minutes from baseline for the intervention group and decreased by 2.6 minutes for the control group (Figure 2).

The findings of sensitivity analysis of the primary outcome, adjusting for age, were consistent with those of the primary analysis. The mean difference in change in daily MVPA between groups of 6.3 minutes was in favor

Table 1. Sample Characteristics at Baseline—Students Wearing an Accelerometer (n=1,150)

Characteristic	Intervention group	Control group
Total participants (n)	645	505
Gender (n)[a]		
Boys	312	246
Girls	333	258
3 valid days	530	435
Age, years (M)	12.0	12.0
Aboriginal and/or Torres Strait Islander (%)	5.3	7.8
Height, m (M)	157.1	156.8
Weight, kg (M)	49.3	50.0
Student BMI category (%)		
Underweight/healthy weight	78.3	73.3
Overweight/obese	21.7	24.7
Student activity level (%)		
Active (≥60 minutes MVPA/day)	33	33
Low active (<60 minutes MVPA/day)	67	67
Accelerometer wear time	793.6	804.6
Mean minutes per day		

[a]Data on gender missing for one participant.
MVPA, moderate-to-vigorous physical activity.

of the intervention group (95% CI=1.9, 10.7, $p<0.005$). Similarly, sensitivity analysis results using multiple imputations were consistent with those of the primary analysis. The mean difference in change between groups of 6.0 minutes per day (95% CI=0.6, 11.3, $p<0.031$) was in favor of the intervention group.

There were significant effects in favor of the intervention group for five of the six secondary physical activity outcomes: minutes per day of VPA, minutes per day of MPA, percentage wear time in MVPA and VPA, and total daily accelerometer counts. There were no significant intervention effects for percentage of wear time in MPA (Table 2).

The intraclass correlation coefficient values for the primary and secondary physical activity variables are reported in Appendix Table 2 (available online).

At the 20% significance threshold, the three-way subgroup interaction terms indicated that time by intervention effects differed only by sex for the primary outcome of daily minutes of MVPA, and the secondary outcome of daily minutes of MPA. A greater effect was observed for male students in the intervention group compared with male students in the control group for minutes of MVPA per day (mean difference in change, 10.4 minutes, 95% CI=2.1, 18.8, $p<0.01$) and minutes of MPA (6.2 minutes, 95% CI=1.7, 10.7, $p<0.015$). A greater effect was also observed for female students in the intervention group compared to female students in the control group for minutes of MVPA per day (mean difference in change, 4.0 minutes, 95% CI=0.1, 8.0, $p<0.05$) and minutes of MPA (2.9 minutes, 95% CI=0.1, 5.6, $p<0.047$) (Appendix Table 1, available online).

At 24 months, program records indicated all five intervention schools implemented six of the seven physical activity strategies (Appendix Figure 1, available online). The exception was Strategy 5 (school policy), with four of five schools having developed a school policy. All intervention implementation strategies were delivered as planned.

In the 24-month survey of intervention group PE teachers (N=35), 88.9% reported using pedometers to increase activity levels in PE, and 58.8% reported incorporating student personal physical activity plans each term. Acceptability data from the PE teacher survey indicated 40.2% enjoyed teaching pedometer-based lessons, 65.6% reported such lessons helped students to increase their physical activity levels during PE, and 67.6% reported that assisting students to develop personal physical activity plans was a useful strategy.

At 24 months, in the survey of intervention group students (n=409), 90.9% reported using pedometers in PE lessons, 28.9% recalled developing a personal physical activity plan, and 56.9% reported participating in organized physical activity at recess or lunchtimes.

Discussion

This study assessed the effectiveness of PA4E1, a multicomponent school-based intervention, in reducing the decline in physical activity among secondary school students. After 24 months, the intervention was effective in increasing daily MVPA in the intervention group compared with a decrease in the control group. As a result, students in the intervention group participated in 7 minutes more MVPA at 24 months compared with the control group. This outcome builds on a previously reported 12-month mid-intervention result of 3.9 minutes more MVPA.[20] The findings suggest that implementation of the intervention by schools in disadvantaged areas has the potential to reduce the decline in physical activity during adolescence.

The observed effect size for MVPA was greater than the aggregate effect size of 4 minutes more MVPA per day

Table 2. Changes in Physical Activity Outcomes From Baseline to 24-Month Follow-up (Midpoint Data Values Also Shown)

	Intervention			Control			Intervention-control	
Outcome	**Baseline, M (95% CI) (*n*=524)**	**Mid-point,[a] M (95% CI) (*n*=352)**	**Follow-up, M (95% CI) (*n*=245)**	**Baseline, M (95% CI) (*n*=435)**	**Mid-point,[a] M (95% CI) (*n*=288)**	**Follow-up, M (95% CI) (*n*=191)**	**Difference in change from baseline to follow-up between treatment group (95% CI)**	**Group X time *p*-value**
Wear time (minutes/day)	796.1 (781.2, 811.1)	796.6 (779.7, 813.4)	832.9 (814.0, 851.9)	804.4 (788.6, 820.2)	799.7 (781.8, 817.6)	800.3 (779.6, 821.0)		
Counts per minute	483.4 (464.3, 502.4)	485.2 (464.7, 505.7)	460.2 (438.2, 482.2)	484.6 (464.6, 504.6)	455.2 (433.5, 476.8)	448.5 (424.9, 472.2)		
Mean total daily accelerometer counts	382,999 (364,464, 401,534)	378,882 (358,957, 398,807)	378,962 (357,546, 400,378)	387,946 (368,707, 407,185)	360,200 (339,358, 381,042)	351,081 (328,186, 373,976)	32,828 (8,157.9, 57,497)	**0.009**
Minutes of physical activity (minutes/day)								
Total MVPA	53.5 (49.6, 57.3)	54.7 (50.7, 58.8)	57.9 (53.6, 62.1)	53.5 (49.5, 57.4)	51.0 (46.8, 55.2)	50.8 (46.3, 55.4)	7.0 (2.68, 11.4)	**0.005**
Vigorous activity	16.5 (14.5, 18.6)	18.2 (16.0, 20.3)	19.7 (17.5, 22.0)	16.7 (14.6, 18.8)	16.1 (13.9, 18.3)	17.4 (15.0, 19.8)	2.5 (0.3, 4.8)	**0.026**
Moderate activity	37.0 (34.7, 39.2)	36.5 (34.2, 38.9)	38.1 (35.6, 40.6)	36.7 (34.4, 39.1)	34.9 (32.5, 37.4)	33.4 (30.8, 36.0)	4.5 (2.0, 7.0)	**0.002**
% wear time								
Percentage MVPA	6.8 (6.3, 7.2)	7.0 (6.6, 7.5)	7.0 (6.6, 7.5)	6.7 (6.3, 7.1)	6.5 (6.0, 6.9)	6.5 (6.0, 7.0)	0.4 (0.0, 0.9)	**0.029**
Percentage vigorous	2.1 (1.9, 2.3)	2.4 (2.1, 2.6)	2.4 (2.1, 2.6)	2.1 (1.9, 2.3)	2.0 (1.79, 2.29)	2.2 (1.97, 2.50)	0.1 (−0.12, 0.35)	**0.009**
Percentage moderate	4.7 (4.4, 4.9)	4.7 (4.4, 4.9)	4.7 (4.4, 4.9)	4.6 (4.3, 4.9)	4.4 (4.2, 4.7)	4.3 (4.0, 4.6)	0.3 (0.0, 0.6)	0.086

Note: Boldface indicates statistical significance ($p < 0.05$).
[a]Mid-intervention effects of the “Physical Activity 4 Everyone” school-based intervention.[20]
MVPA, moderate-to-vigorous physical activity.

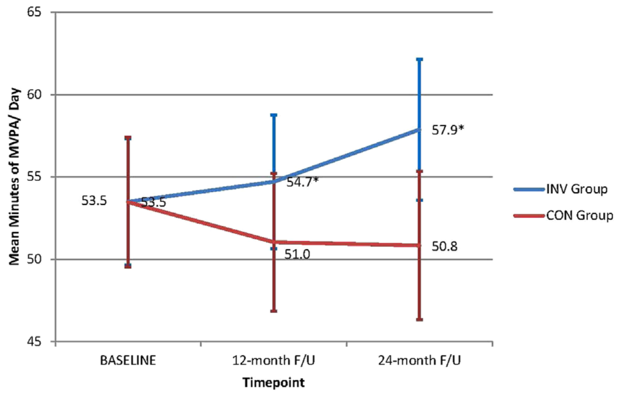

Figure 2. Mean minutes of MVPA per day for intervention and control group students at baseline and at 12-month (mid-point) and 24-month follow-ups.
*Significant difference between the intervention and control groups.
MVPA, moderate-to-vigorous physical activity.

reported in a recent meta-analysis of objectively measured school-based physical activity interventions implemented for children and adolescents.[68] No previous intervention studies that have involved disadvantaged adolescent participants have reported a statistically significant effect using objectively measured MVPA at 12 months or more follow-up.[15–19] No comparable trials have reported a significant MVPA effect for both male and female students separately, and for MPA and VPA separately.

The contrasting positive effects observed in this study relative to the findings of past interventions may be attributable to a number of the design elements: an extended intervention duration (average of 24 months)[12]; the use of a theory-based intervention; the inclusion of multiple physical activity promotion strategies[11,12,20]; and the inclusion of multiple strategies, particularly the in-school physical activity consultant, to support school implementation of the intervention strategies.[12] No previous secondary school-based studies targeting disadvantaged adolescents have included all such intervention elements. The extent to which the inclusion of such elements contributed to the contrasting findings is unknown and requires further research.

The finding of a greater intervention effect on duration of MVPA activity at 24-month follow-up, compared with the previously reported 12-month result, strengthens previous suggestions that a dose–response relationship exists between length of intervention and extent of effect on adolescent physical activity.[11,21] Further research is warranted to determine the incremental benefits of extending the length of intervention further, for example, implementation on a routine basis throughout the first 4 years of secondary schooling. In addition, further analysis to determine the impact of the intervention on weight status would add to the body of literature regarding the merit of school-based physical activity intervention and obesity prevention.

The intervention had a significant and positive effect on daily MVPA for both male and female students. However, the intervention effect for male students appeared to be approximately 2.5 times that for female students. The MVPA levels of female students in the intervention group remained stable over the 24-month period, whereas they decreased for female students in the control group. By contrast, MVPA consistently increased for male students in the intervention group. As female students are less likely to participate in physical activity than male students,[3] these findings suggest that additional intervention strategies targeting female students may benefit future interventions (e.g., single-sex PE lessons or sport, focus on non-competitive activity).[69,70]

Limitations

The study has a number of strengths, including use of a cluster RCT design, extended intervention duration, objective measurement of physical activity, and the inclusion of a suite of intervention implementation strategies as recommended in past school-based physical activity reviews. A limitation of the study is the loss of participants at follow-up, with less than half of the students that initially consented providing accelerometer data at 24 months, a finding consistent with previous studies.[14,17,71] Accelerometer compliance may be improved by the provision of compensation strategies such as monetary incentives, class points, rewards, and non-monetary incentives for wearing the accelerometer or for correct wear time, particularly for older students.[57,72,73] Alternatively, wrist-worn accelerometers may promote compliance.[74] Nonetheless, analysis of outcomes that adjusted for variables associated with loss to follow-up and analysis using multiple imputation for missing data indicated similar findings to the primary analyses, suggesting consistency in direction of the effect. Secondary outcomes for percentage of wear time spent in MVPA and VPA were also consistent with the main trial outcomes over time. MPA shows a positive trend, although statistically not significant, perhaps owing to limited power to detect an effect on this scale. The subgroup analyses indicated no intervention effect by baseline levels of BMI or physical activity despite such variables being shown to be moderators of energy balance.[65] This finding may be attributable to the study not being adequately powered to detect such differences, or to other factors. Future adequately powered studies are required to better understand the impact of such moderators on intervention effectiveness.

Conclusions

The PA4E1 intervention was effective in increasing daily minutes of MVPA in the intervention group compared with a decrease in the control group for all students and for female and male students. Findings suggest that implementation of the intervention by disadvantaged schools has the potential to reverse the decline in physical activity in this population group. Further research is warranted to determine the potential to benefit adolescents from a range of schools, regardless of SES of the school community, and its impact if implemented on a routine basis throughout secondary schooling. Additionally, although review evidence indicates that physical activity benefits achieved from multicomponent school-based interventions are sustainable,[75] few long-term follow-up studies have been published. Further follow-up assessing school practices and student physical activity would determine if implementation has been maintained and impact sustained beyond the intervention. Assessment of the intervention impact on school day physical activity should also be explored in addition to cost and cost effectiveness.

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The research team acknowledges the importance of making research data publically available. Access to the accelerometer data from this study may be made available to external collaborators following the development of data transfer agreements. Further results arising from the study can be found at www.goodforkids.nsw.gov.au/high-schools/.

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Appendix

Supplementary data

Supplementary data associated with this article can be found at http://dx.doi.org/10.1016/j.amepre.2016.02.020.