Effects of a 10-week integrated curriculum intervention on physical activity, resting blood pressure, motor skills and well-being in 6–7-year-olds

Duncan, M., Fitton Davies, K., Okwose, N., Harwood, A. E. & Jakovljevic, D.

Original citation & hyperlink:
Duncan, M, Fitton Davies, K, Okwose, N, Harwood, AE & Jakovljevic, D 2024, 'Effects of a 10-week integrated curriculum intervention on physical activity, resting blood pressure, motor skills and well-being in 6–7-year-olds', Journal of Physical Activity & Health, vol. (In-Press), pp. (In-Press).
https://dx.doi.org/10.1123/jpah.2023-0239

DOI 10.1123/jpah.2023-0239
ISSN 1543-3080
ESSN 1543-5474

Publisher: Human Kinetics

Effects of a 10-week integrated curriculum intervention on physical activity, resting blood pressure, motor skills and well-being in 6–7-year-olds

Michael J. Duncan[1*], Katie Fitton Davies[2], Nduka Okwose[1], Amy E Harwood[1], Djordje G. Jakovljevic[1]

[1]Institute of Health and Wellbeing, Coventry University, Coventry, UK

[2]Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, UK

Corresponding author: Michael J. Duncan, Institute of Health and Wellbeing, Coventry University, Coventry, UK. Email: aa8396@coventry.ac.uk

Running Head: Integrated Curriculum Interventions

Word count: 4900

Background: Integrated curriculum interventions have been suggested as an effective means to increase physical activity (PA) and health. The feasibility of such approaches in children living in deprivation is unknown. This study sought to pilot an integrated curriculum pedometer intervention in children living in deprivation on school-based PA, body fatness, resting blood pressure, motor skills and well-being.

Methods: Using a pilot cluster randomized intervention design, children (6-7-years-old, n=64) from two schools in central England undertook: (1) 10-week integrated curriculum intervention or (2) control (regular school-based activity). School-based PA, body fatness, resting blood pressure, motor skills and well-being was assessed pre and post intervention.

Results: for the intervention group PA was higher on school days when children had PE lessons or there were physically active integrated curriculum activities. Body fatness significantly decreased, wellbeing and perceived physical competence increased, pre-post for the intervention group compared to the control group. Accelerometer derived PA, motor skills and resting blood pressure were not significantly different pre-post for intervention or control groups.

Conclusions: A 10-week integrated curriculum PA intervention is feasible to conduct and can positively impact aspects of health in 6–7-year-old children in England.

Keywords: Health, Deprivation, Pediatrics, School, Education

Introduction

The benefit of physical activity (PA) on children's health and well-being is well established.[1] Increasing PA is a key strategy to curb increases in childhood obesity, mental health issues and other lifestyle related diseases in children and youth. [1] Despite this, there remain concerns that children do not engage in sufficient PA for health benefits,[2] mental health issues are increasing,[3] and children are not developing the fundamental movement skills needed to engage in PA for life.[4] Children coming from more disadvantaged areas are also often the least active[5] and demonstrate poorer health profiles than their more affluent peers[6] with such profile being delayed even further as a result of the COVID-19 pandemic.[7]

The school is an important environment for children and is consistently cited as one location where attempts to promote PA may be particularly successful.[8,9] While both Personal, Social and Health Education (PSHE) and curriculum Physical Education (PE) are important in this context, there is a recognition from Public Health England[9] and the World Health Organization (WHO)[10] that there are educational and other benefits of PA beyond PSHE and PE. The WHO acknowledges schools should not be the sole location where children undertake PA.[10] However, due to children spending more time at school than anywhere, other than the home, schools represent an excellent opportunity for PA promotion. [10] This is especially the case for children living in deprived areas, who face additional barriers to undertaking PA outside of school environments.[10]

One means by which PA has been embedded within schools is through integrated curriculum approaches. Accumulating PA throughout the school day via active travel, active play, incidental activity and active lessons is an effective means to increase total daily PA.[11] Systematic review data have shown that school-based interventions can positively influence: Duration of habitual PA, TV viewing time, maximal exercise capacity and blood cholesterol.[12] However, there is considerable variation in the types of school based interventions that use the term 'integrated' with some simply adding physical activity into the school day, such as 'energizer breaks' where short bouts of PA are performed in school time,[13,14] to studies which add activity into specific school lessons such as maths[15] and English,[16] to studies which fully integrate PA in multiple aspects of the curriculum to embed physically active learning in more than one area of school life. [17,18,19] For any positive effect to be seen using an integrated curriculum model, it has been suggested that as a minimum, changes to the curriculum are needed alongside some additional material, such as booklets, posters and visual aids.[12] There are some studies which have demonstrated the potential for such integrated curriculum models to enhance PA in school time using the approach stated above, and focusing on more than one aspect of the school curriculum, including an open-loop feedback and monitoring mechanism for PA behaviour change. [17,18,19]

Oliver et al.[17] employed an integrated curriculum model, using pedometers over a 4-week period in a convenience sample of 78, 8–9-year-old school children from New Zealand. This intervention centred around increasing PA in school to virtually walk to various cities in New Zealand. PA was integrated into the curriculum in different school subjects. In English, children were asked to read about the different cities the children were virtually walking to. In social studies, children investigated how technology had changed through history in the context of measuring PA. In mathematics, children used the step count data to calculate stride length and distance walked. Oliver et al. did not report a significant improvement in habitual PA over the course of the intervention but did report a significant improvement in average steps/day as a consequence of the intervention for those children that accumulated less than 15,000 steps/day at baseline.[17]

Duncan et al.[18] used a similar approach to that of Oliver et al.[17] where 59 English children, aged 10-11 years, were challenged to walk the length of the United Kingdom (from John O'Groats to Lands' End) over a 4-week period. Children wore a pedometer every day to record step counts. The curriculum was modified by the school to integrate PA into geography, science, mathematics and information technology lessons. Duncan et al.[18] reported a significant increase in average steps/day during the intervention and four weeks post-intervention compared to baseline (p = .0001). This effect was consistent between boys and girls.

In the only other published study to date using such an integrated curriculum model, Eyre et al.[19] employed a 6-week integrated curriculum and pedometer-based intervention in a sample of 134 multi-ethnic 9–11-year-olds. Unlike prior work, Eyre et al.[19] utilised an intervention group and a control group, reporting that average daily steps were significantly higher at 6-weeks post intervention compared to baseline for the intervention group. School lessons in science and PE were integrated into the curriculum alongside cross-curricular links in literacy, art, and music.

However, there are several limitations in prior work using an integrated curriculum approach. The work by Oliver et al.[17] and Duncan et al.[18] used a pre-post design with no control group. All prior studies on this topic have used pedometry as both the outcome measure of PA and the mechanism by which the children gauged their progress throughout the intervention. This is despite prior work suggesting that in such interventions, different measures of PA need to be used as outcome measures and as the mechanism by which PA feedback is gained by participants.[20] Of note, there is consistent evidence that school-based interventions can positively impact children's mental health and well-being,[21] cardiovascular health[12] and motor competence.[15] Yet, the majority of interventions to date have tended to target single health related outcomes. This is despite an acknowledgement that whole school interventions have potential to change multiple health related behaviours.[22] This is because multi-behavioural interventions (i.e., those containing different components) are hypothesized to have synergistic effects of different aspects of health,[22] and can target different clusters of health outcomes, or 'super-domains' of outcomes .[22] Such an approach has only been demonstrated for school-based interventions with adolescents and targeting super domains of addiction related outcomes (i.e., smoking, alcohol and drug-use) and energy balance related outcomes (i.e., sedentary behaviour, physical activity).[22] Theoretically, an integrated school curriculum model focused on PA is likely to act on different outcomes such as those relating to well-being, motor skills, and cardiovascular health as all these constructs are influenced by PA. To date, prior work using integrated curriculum models has only focused on PA and obesity metrics as outcome measures with results of such studies suggesting a synergistic effect on these two types of outcomes. [17,18,19] The effect of integrated curriculum approaches in younger age ranges (e.g., Key Stage 1 in the English curriculum) has not been investigated although it has been a recommendation of prior studies. [17,18,19]

The present study sought to address these gaps by piloting a 10-week integrated curriculum pedometer intervention in 6–7-year-olds living in a deprived part of England and examining effects on school-based PA, body fatness, resting blood pressure, motor skills and well-being.

Methods

This study employed a repeated measures approach, with a cluster randomized intervention design where children from two schools in central England were allocated into two conditions: (1) integrated curriculum intervention or (2) control (regular school-based activities). The schools involved were comparable in terms of ethnicity and were located in electoral wards adjacent to each other that were ranked within the top 10% most deprived areas nationally based on the Index of Multiple Deprivation.[23] All participants were drawn from year 2 classes (ages 6–7). Allocation to intervention or control conditions was done by chance (coin toss). The control group undertook a 10-week integrated curriculum pedometer intervention whereas the control group continued their normal curriculum activities. The curriculum activities for the two schools did not differ other than the intervention activities during the intervention period. Randomization took place at the school level.

Participants

Sixty-four children aged 6-7 years (37 boys, 27 girls; Mean ± SD = 6.3 ± 0.5 years) from two central England primary schools (one school class per school) participated in this study following institutional ethics approval, written informed parental consent, and child assent. One class (n=32) comprised the intervention group and the other class (n=32) comprised the control group. On completion of the intervention period, complete data were available for 60 children, where four children (all girls) were not included in final data analysis due to moving school during the intervention period (n=1), illness resulting in significant time away from school during the intervention period (n=2) or absence during data collection periods (n=1). Ethnic classifications of participants were: 90% 'Caucasian;' 7% 'South Asian;' 1.5% 'East Asian', 1.5% 'Black'. Inclusion criteria comprised being a child in school year 2 in the schools taking part, not having a registered special educational need, nor any form of musculoskeletal issue that would impair movement. It is generally accepted that pilot studies do not require a formal power calculation.[24] However, this study recruited ~30 children per group as per pilot study sample size recommendations.[25,26]

Integrated Curriculum Intervention

Children undertook a 10-week, school-based pedometer intervention using an integrated curriculum model. The intervention followed processes previously employed with older children and over shorter timespans.[17,18] The intervention took the form of a virtual challenge where children were asked to walk the length of the London underground train route over the 10-week period. Prior to the intervention, we conducted a brief interview with the teacher of the intervention class. Here, we explored how the intervention might effectively integrate with the curriculum. At the time the intervention was to take place, the children's topic was 'London'. Thus, citing the pedometer challenge aspect of the intervention of walking the London underground linked to the cross-curricular topic the children were engaging with during the school term, and gave context to the other activities included in the integrated curriculum intervention.

The intervention itself used interlinking elements to create opportunities to increase PA with a goal to increase PA levels by at least 2000 steps per day from baseline, as this increment is associated with a significant reduction in cardiovascular risk.[27] The intervention took a standard framework for delivery and administration whilst at the same time allowed an individualised approach to increasing PA. Scaffolded by previous research using integrated curricula,[18,19] and co-developed with classroom teachers, this intervention comprised two elements.

The first element was designed to increase opportunities for PA throughout the school day via the use of the step-based challenge of walking the London underground. This stage directly supports the increase of steps per day for each child by providing an open loop feedback mechanism to motivate the children to engage. This was achieved by providing each child with a piezo-electric pedometer (New Lifestyles NL-1000) and a 'challenge pack' which included maps of each trainline, split into stages, alongside step-logs and a progress bar related to their progress relative to the overall challenge. Children were given autonomy to record their step counts at the end of each school day in their individual challenge thereby giving them ownership of the process. At the end of each school week a researcher attended the school and logged the steps the children had accrued. Importantly, the NL-1000 pedometer employed in the present study had an internal memory, so the fidelity of children's reporting versus the actual septs recorded could be verified. At each of these weekly points the researcher visually 'filled' each child's progress bar and ticked off each stage of the London underground the child had completed during the course of the week's activities. This process employed elements of gamification including levels/stages, and visual progress related to an overall goal to maintain children's engagement in the process. We used a conversion rate of 700 steps to 1 mile to visually log progress.

The second element of the intervention was designed to provide an environment that promotes the benefits of PA in schools in a way that was pragmatic for teachers recognising there is a crowded school curriculum. In Key Stage 1 (ages 5-7), children follow themes across their academic subjects; therefore, supplanting a 'physical' theme across curriculum subjects such as science, art, mathematics, and geography is a natural accommodation for the children and teachers. This approach also follows prior work with older children.[18,19] To achieve this, the curriculum was modified by the school to integrate active lessons into different aspects of school life linking the intervention challenge with the curricula theme of London. During PE lessons, children were provided with educational sessions relating to the role of PA in maintaining healthy weight. In geography lessons, children used the data to track their progress in walking the length of the London Tube in relation to topographical maps of London and also took part in active lessons relating to reading/interpreting maps which required movement/accrual of steps to complete. In history lessons, children took part in active lessons where they walked (including measurement of) the distance of the great fire of London, and the London Wall on the school playground. Other active sessions included walking the height of London Landmarks such as 'the Shard' in mathematics and information and communications technology lessons and then using the step data for creating graphs. During the 10-week intervention period, in addition to curriculum PE, there were two other fully active lessons each week (i.e., PA was undertaken throughout the whole lesson) that were undertaken in subjects other than PE.

Collectively, the intervention design incorporating the London Underground challenge with individualised progress, printed materials, and challenge book, alongside changes to the curriculum, adhered to the recommended changes required to influence school-based PA.[12]

Measures

At pre- and post-intervention, each participant undertook assessment of PA, anthropometry, resting blood pressure, motor skills and well-being. In addition, school PA was assessed each day of the intervention period for the intervention group, but not the control group.

Primary outcome

Physical activity monitoring. Children wore an accelerometer (ActiGraph GT9X; FL, USA) over a 7-day period on their non-dominant wrist with data collected at 100Hz and in 5 sec epochs. The device was worn throughout the day and removed for sleeping, when having a bath, swimming or for safety reasons. All children were provided with a diary to note times children took off the accelerometer. The time spent in sedentary behaviour, light, moderate and vigorous intensity PA was determined using child-specific cut-offs.[28] These cut offs are described a reliable and recommended for use to assess PA in children of the ages participating in the present study.[29] The accelerometer was worn one week prior to the intervention starting and one week after the intervention had concluded. Accelerometer data collection and processing followed guidelines proposed by Migueles et al for dealing with accelerometry with children.[29] Recognising that there is no consensus on non-wear time definition for accelerometer derived PA in children, where 10mins of consecutive zeros up to 90mins of consecutive zeros have been suggested, non-wear time was considered as 60mins of consecutive zeros in line with recommendations form Migueles et al.[29]

For the intervention group, steps/day during the intervention period were collated based on the pedometer derived data (New Lifestyles NL-1000) for each day of the intervention. Steps/day were retrieved at the end of each school week from the internal storage memory of the pedometer. The pedometer employed was chosen as it has shown one of the highest reliability and validity coefficients in children and across weight status groups[30] and has been successfully used in similar studies previously.[18,19] Prior to the monitoring period, children were familiarized with the pedometers (all children had prior experience wearing pedometers as part of school science classes) including pedometer attachment, removal, and reattachment.

Secondary outcomes

Resting arterial blood pressure. Resting blood pressure was assessed by trained researchers in the school setting. Children were assessed in a seated position, with feet flat on the floor on an individual basis and following a 10-15-minute rest period. Measurements were taken in the morning using an automated oscillometric device (Omron HEM907XL; Omron Healthcare Europe BV, Hoofddorp, The Netherlands). The blood pressure cuff was applied to the right arm with the lower margin of the cuff approximately 2cm above the elbow crease and with the arrow on the cuff aligned with the brachial artery. The cuff was wrapped to a tightness allowing two fingers to be inserted under the top and bottom of the cuff. Cuff size used was determined based on mid-upper arm circumference. Three consecutive measurements were taken at minute intervals. The first reading was discarded and the mean of the second and third measurements was used for analysis in line with prior research[31]and because the first reading of a series of blood pressure measurements is typically higher with oscillometric devices.[32] Assessment of blood pressure followed recommended guidelines for determination of resting blood pressure in pediatric populations[33] and the monitor used in the present study is valid and reliable when compared to manual sphymomanometry.[34]

Anthropometry. Stature was measured using a stadiometer (Leicester portable height measure, UK) to the nearest 1mm. Body mass was measured to the nearest 0.1kg using weighing scales (Tanita inc. Tokyo Japan). Body fat percentage was also determined using leg-to-leg Bioelectrical impedance analysis (BIA) (Tanita inc. Tokyo Japan, BF350) as this form of assessment has been demonstrated to be valid, reliable, and practical for the estimation of body fatness in children.[36] Moreover, the BIA monitor employed in the present study is deemed reliable to assess percentage body fatness in children of the ages involved in the present study being, associated with r values of >.87 compared to dual x-ray absorptiometry derived fatness.[36]

Motor skill. The Test of Gross Motor Development-3rd Edition was employed as a measure of gross motor competence in the present study.[37] The TGMD comprises a series of skills, categorised into two classes of movement: locomotor and object control. In the current study the following skills were assessed: Run, Jump, Overarm Throw, Catch. These skills were specifically chosen as they are the fundamental motor skills identified by the National Curriculum for Physical Education in England which children should be proficient in by the end of school year 2. All skills were video recorded (Sony video camera, Sony, UK) and subsequently edited into single film clips of individual skills on a computer using Quintic Biomechanics analysis software v21 (Quintic Consultancy Ltd., Birmingham, UK). Scores from two trials were summed to obtain a raw score for each skill. The scores for all the skills were then summed to create a total motor competence (scored 0–40) score following recommended guidelines of administration of the TGMD-3.[37] Two researchers experienced in the assessment of children's movement skills (having previously assessed movement skills in the context of a previous research study) analysed the motor competence videos. Congruent with prior research,[38] training was considered complete when each observer's scores for the two trials differed by no more than one unit from the instructor score for each skill (>80% agreement). Intraclass correlation coefficients for inter and intra-rater reliability were 0.925 (95% CI = 0.87–0.95) and 0.987 (95% CI = 0.94–0.98), respectively, demonstrating good reliability.[39]

Well-being. The Short Mood and Feelings Questionnaire (SMFQ) is a shortened version of the 33-item Mood and Feelings Questionnaire and was used to assess general well-being in participants aged 6-17 years.[40] The SMFQ contains 13 items and assesses the presence of affective and cognitive symptoms related to depression and general well-being over the past two weeks on a 3-point scale (0=*not true*, 1=*sometimes*, 2=*true*). Total SMFQ scores range from 0 – 26. The tool takes approximately 5 minutes to complete and has been validated in children of the ages taking part in the present study.[41,42] The assessment of well-being was undertaken on a one-to-one basis with each participant and a trained researcher. Good discriminant validity of the SMFQ has been demonstrated though clear distinctions between psychiatric and paediatric, depressed and non-depressed, populations.[40] Internal reliability is high (Cronbach's alpha = 0.85), with 60% sensitivity and 85% specificity with a cut off score of 8 or more, which is recognised as the cut-off for clinical depression in children aged 6-17 years. [40]

Perceived physical competence. Children's perceived skill competence was assessed using the Pictorial Scale of Perceived Movement Skill Competence for Young Children 3rd Edition.[43] Children were asked to rate their perceived competence in running, jumping, overarm throwing and catching (to match the assessment of actual motor skills in the present study) on a four-point scale where 4 represents the highest degree of perceived competence. Items were summed to create an overall perceived movement skill competence scale score which ranged from 4 to 16 with higher scores reflecting greater self-perception of competence in motor skills. The Pictorial Scale of Perceived Movement Skill Competence for Young Children demonstrates validity in distinguishing children with better or poorer movement patterns[43] and two week test-retest reliability data, from our laboratory, in subsample of children (n = 43; 22 boys, 21 girls; mean age = 5.6, SD = .48 years), indicated good agreement (Intraclass correlation coefficient = .86, CI = .74 - .92) and internal consistency (Cronbach's α =.89) for the total perceived physical competence score.[44]

Class teacher reflections on the intervention

Once the intervention had been completed, a brief (20min) one to one interview was held with the class teacher of the intervention group to capture their reflections of the intervention. The interview process was based on recommendations for conducting qualitative research and validation of interview scheduling.[45] The interview used a structured guide with open questions and asked four main questions, 1. What did you consider were any positive outcomes from the children engaging in the intervention? 2. What did you consider were any negative outcomes from the children engaging in the intervention? 3. What were any challenges you faced when implementing the intervention with your class? 4. What ways might the intervention be better if we were to roll this out in other schools? Prior to the interview, the interviewer followed the eight-stage interview preparation stage identified by McNamara[45] and was led by one facilitator. Probing was used throughout the interview to gain further understanding. The interview was transcribed verbatim. The transcript was analysed using inductive analysis following the steps proposed by Braun and Clarke such as familiarisation of data, reading and re-reading the data, code generation, categorisation, search and reviewing themes and defining and naming themes.[46] Analyst triangulation was conducted to increase quality and credibility of findings.[47]

Statistical analysis

To examine any differences in primary and secondary outcome variables a series of univariate analysis of covariance (ANCOVA) were used with change scores for each variable as the dependent variable and baseline values for each variable as the covariate. This approach was employed as research suggests that analysis using ANCOVA on intervention change scores, and controlling for baseline, results in the least biased analysis technique where there has been no control in the pre and post treatment variance.[48] Such as is the case in studies such as the present study, and others, where data is not collected using a matched design where pre-test variance in baseline scores can be controlled between intervention and control groups.[48] The ANCOVA approach we employ with change scores is also recommended where there is significant correlation between baseline and post scores and avoids regression to the mean.[49] Group (Intervention vs Control) was used as between subjects' factors. Partial $P\eta^2$ was used as a measure of effect size. Where any significant differences were found post hoc, pairwise comparisons (Bonferroni adjusted) were employed to examine where the differences lay and Cohen's d was used to further identify effect size. Independent samples t-tests were used to examine any differences in outcome variables between intervention and control groups at baseline and between boys and girls at baseline. The Statistical Package for Social Sciences (SPSS, Version 28, IBM Corp, Armonk, New York) was used for all analysis. Given the limitations of data presentation using bar graphs showing only mean ± SD, primary and secondary outcome variables were visually presented as a means and data distribution in figures to ensure more complete presentation of data following procedures advocated by Weissgerber et al.[50]

Results

Mean ± SD and 95% Confidence Intervals for primary and secondary outcome variables at pre and post for intervention and control groups are presented in Table 1.

Table 1 here

There was no difference in PA, DBP, BMI, Body fat percentage, SMFQ, PMC and FMS scores at baseline between intervention and control groups (all P>.05) although at baseline, SBP (P=.008) was significantly higher for the intervention group, compared to the control group. Likewise, boys reported significantly greater perceived physical competence (P=.007) and motor skill scores (P=.03) at baseline. This is congruent with prior studies examining actual and perceived motor skills in children.[4]

Physical Activity

Pre-Post

When accelerometery derived time spent in sedentary behaviour, light, moderate and vigorous PA pre and post intervention during school time was considered, there was no significant change in any of the aforementioned variables pre-post for either intervention or control group (all P>.05).

Ambulatory PA during the intervention

The average steps/day undertaken by the intervention group during the intervention demonstrated that the steps/day accrued during the school-based intervention itself accounted for 36-41% of the recommended total steps/day for health in children.[51] When daily steps were considered on a day-by-day basis (See Figure 1), steps accrued were higher on school days when children had statutory PE lessons or there were physically active integrated curriculum activities. There was not a marked difference in the steps accrued on days when children had PE lessons, compared to days when they were involved in physically active integrated curriculum activities. Figure 2 presents the mean ± SD of steps accrued during each day of the intervention period identifying days when physically active integrated curriculum activities took place (Dotted bars) and days when statutory PE took place (Chequered bars). Of note, there was no marked reduction in the steps accrued during school time across the intervention period.

Figure 1 here

Resting Blood Pressure

For SBP, the change in SBP was not significantly different pre-post, controlling for baseline values ($F_{1,57}$ = 2.742, P = .103, Pη^2 = .046), nor was baseline SBP significant as a covariate (P =.502). This finding was replicated for DBP which was not significantly different pre-post, controlling for baseline values ($F_{1,57}$ = 2.978, P = .09, Pη^2 = .05), nor was baseline DBP significant as a covariate (P =.778).

Body Fatness

For percent body fatness, there was a significant difference pre-post ($F_{1,57}$ = 10.633, P = .002, Pη^2 = .157, See Figure 4). Bonferroni post hoc pairwise comparison indicated that there was a greater change in body fatness for the intervention group (-1.26 ± 2.2) compared to the control group (.335 ± 1.6), whereby percent body fat decreased for the intervention group but not the control group with Cohen's *d* (*d*=0.29) indicating a small effect size. Percent body fat at baseline was also significant as a covariate (P=.023, β = -.121) indicating that higher percent body fat at baseline was significantly associated with a greater reduction in percent body fat at the end of the intervention.

Figure 2 here

Motor Skill, Well-Being, and perceived physical competence

For motor skill, total FMS scores were not significantly different pre-post, controlling for baseline values ($F_{1,57}$ = 1.28, P = .263, Pη^2 = .022), nor was baseline FMS significant as a covariate (P =.500). In regard to measures of well-being the SMFQ and perceived physical competence, results for the SMFQ revealed that there was a significant difference pre-post ($F_{1,57}$ = 13.2, P = .001, Pη^2 = .524, See Figure 3). Bonferroni post hoc pairwise comparison indicated that there was a greater change in SMFQ scores for the intervention group (-2.32 ± 2.1) compared to the control group (-.56 ± 1.7), with Cohen's *d* (*d*=0.59) indicating a medium effect size. whereby SMFQ scores decreased for the intervention group to a greater extent than the control group. SMFQ scores at baseline were also significant as a covariate (P=.001, β = -.414) indicating that higher SMFQ scores at baseline (i.e., poorer well-being) was significantly associated with a greater reduction in SMFQ scores (i.e., better well-being) at the end of the intervention. Similarly, there was also a significant difference in perceived physical competence pre-post ($F_{1,57}$ = 8.356, P = .005, $P\eta^2$ = .128, See Figure 4) with Bonferroni post hoc pairwise comparison indicating that there was a greater change in perceived physical competence scores for the intervention group (-740 ± 1.2) compared to the control group (.134± 1.0) with Cohen's *d* (*d*=0.26) indicating a small effect size. Baseline scores for perceived physical competence as a covariate was not, however, significant (P = .505).

Figure 3 here

Figure 4 here

Teacher Reflections

The teacher reflection (n=1) produced additional insight into how the intervention worked from the teacher's perspective. Recognising this was a brief interview and with the teacher who administered the intervention, this should really be considered a snapshot. Thematic analysis revealed one main theme focused on intervention delivery and outcomes. The themes from this reflection is presented in Figure 5. Key aspects that were raised by the teacher centred around the needs to plan the intervention sessions, considered additional workload, that the intervention was more challenging to run for children with additional needs, and the use of pedometers as being an additional demand on school time. The teacher suggested solutions to develop the intervention further including using apps-based technology and/or involving family units more widely.

Figure 5 here

Discussion

The present study pilot tested a 10-week integrated curriculum pedometer intervention in 6–7-year-olds living in a deprived part of England. The results of the present study demonstrate the feasibility of using an integrated curriculum approach to engage 6–7-year-old children living in deprived areas in school-based PA. This is the first study to examine the possibility of using integrated curriculum PA interventions with children in Key Stage 1 of the English curriculum, and also the first to employ an intervention period lasting a whole term.

The results of the present study suggest that, compared to control group, those children who undertook the intervention experienced a reduction in body fat percentage and an improvement in mental well-being and perceived physical competence pre to post. There was no significant change in systolic or diastolic blood pressure or motor skills pre to post for intervention for intervention or control groups, although the study was not formally powered to detect a significant change. Participation in the intervention itself during school hours contributed approximately 40% of children's recommended PA for health. On days where integrated curriculum PA sessions took place the level of PA was comparable to, or in excess of, school days where statutory PE took place. This is suggestive that for PA, integrated curriculum days buffered the effect of non-PE days, providing a means to engage children in school time PA, on days where they traditionally would not be as active. We therefore argue that this integrated curriculum approach adds value in terms of school-based PA. Such an assertions aligns with suggestions made by prior authors regarding the potential for school-based interventions, especially those that embed PA opportunities within the curriculum, to positively impact multiple health outcomes.[13,14,15,16] However, although PA via steps/day was increased during the intervention period for the intervention group, there was no significant difference in accelerometer derived PA or sedentary behaviour assessed before and after the intervention period. This would suggest that participating in the intervention itself increased school-based PA rather than it leading to PA change post intervention.

From a behaviour change perspective, contextualising the integrated curriculum intervention trialled in the present study with the COM-B model within the Theoretical Domains Framework[52] may help highlight how and why an integrated curriculum intervention works. According to the COM-B for a given behaviour to occur an individual must have the capability and opportunity to engage in the behaviour, and the strength of motivation to engage in the behaviour must be greater than for any other competing behaviour at a given time. Within the integrated curriculum intervention in the present study, embedding PA within different curriculum areas works extensively on the opportunity component of the COM-B model. By embedding PA within different curriculum areas within school there are a significantly increased number of opportunities to be physically active throughout the day, which are also reinforced by the social norm of a whole class undertaking the intervention. The use of open loop feedback, via step counting and including staged section (ie the different train lines on the London Underground) works on the motivation aspect of the COM-B model. By situating the intervention in a personal challenge within the whole class, the open loop feedback from step counting acts on reflective motivation (i.e., participants have a goal which aligns to their intentions) which subsequently should work on automatic motivation (as the integrated curriculum sessions themselves should facilitate associative learning habits and drives). The capability aspect of the COM-B is implicit within the intervention. As the intervention itself focuses on step counts, the participants all have the physical capability to undertake the task itself. Of note, although the intervention did elicit some positive changes in some of our outcome variables, there was no effect on our primary outcome variable of PA. The results in the context of behaviour change are explainable in that, when the intervention was withdrawn, accelerometer derived PA was not different to pre-intervention. Thus, without the intervention, the opportunity aspect of the COM-B model reverted back to a standard school curriculum where there were fewer opportunities to engage in PA during the school day, and the motivation aspect of the COM-B also changed, where the lack of goal driven, open loop feedback process (via step counting to walk the different stages of the London Underground) may have resulted in a reduction in motivation to engage in PA behaviour.

Consequently, the results of the present study would suggest that longer term planning is needed to maintain increases in PA seen during the intervention we trialled in the current study. Use of behaviour change techniques could be useful here for researchers seeking to implement integrated curriculum models in schools over a longer period than that used in the present study. However, when considering this possibility, it is also relevant to bear in mind the qualitative reflection made by the teacher in the present study. While schools are seen as an environment where PA can be effectively promoted[8,9] the demand on teaching staff when embedding such interventions in practice needs to be considered. From the teacher reflection, there was acknowledgement that the intervention had benefit and was seen as positive, but also that, to undertake it, there was a need to undertake additional work in terms of planning lessons to link to the step-based challenge, as well as ensuring that children legged steps effectively during the intervention itself. A logical next step when trying to further develop the integrated curriculum intervention we have trialled in the present study, may be to undertake a co-development process with teachers to refine the intervention, whilst also exploring how to effectively overcome challenges that teaching staff may face when implementing the intervention, such as the increased planning time noted by the teacher in the present study.

Engaging children living in deprived communities in PA has been identified as a key target for non-communicable disease prevention.[53] Children living in such circumstances are hard to reach and the school setting is recognised has having significant potential to effect PA promotion. Of particular concern, children living in deprived areas of England have high levels of inactivity and poorer levels of their fundamental motor skills.[53,54,55,] Any opportunity to increase PA is useful in enhancing the health of a population where 65% of 7–9-year-olds fail to meet PA guidelines for health.[55] The results of the current study demonstrate evidence of promise in this regard and, we would suggest, the results of the present study merit further exploration.

There are many recognised barriers which prevent children living in deprived areas engaging in the amount of PA needed for health benefit and it is recognised that there are many overlapping, interrelated and complex factors which influence opportunity to engage in PA for such children.[56] The socio-ecological model of health[57] as applied to PA[58] suggests that multiple factors, from intrapersonal and interpersonal to organisational, community and policy combine to influence opportunity for PA. This is particularly the case for children living in deprived areas in England.[53] The results of the present study are important in this respect. The integrated curriculum model developed and piloted in the current study, addresses multiple aspects of the socio-ecological model in unison, targeting intrapersonal factors at the child level, interpersonal factors at the level of the teacher and school class and organisational level by targeting the school environment.

The current study is not without limitations, as a pilot study, we recognise that sweeping conclusions regarding the utility of integrated curriculum interventions for PA cannot be made. However, the changes observed in the present study are important for public health and merit further exploration in subsequent research. The results of the present study are also restricted to the age range and population examined, so may not be extrapolated to other demographics. The research was also conducted as a pre-post design, so no longer-term follow-up of any effect on outcome variables was performed. As a pilot study, we ought to explore the potential of the integrated curriculum approach in 6–7-year-old children living in deprived areas, so a longer-term follow-up was not initially intended. Including a longer-term follow-up, to examine if the integrated curriculum intervention resulted in longer-term changes to our outcome variables, would be useful.

Conclusions

The present study suggests that a 10-week integrated curriculum PA intervention is feasible to conduct in 6–7-year-old children. Mental well-being and body fatness were positively impacted because of the intervention compared to controls and undertaking the integrated curriculum intervention contributed approximately 40% of the recommended daily PA for health.

Funding: This research project was funded by the Investigator Initiated Study grant provided to Professors Jakovljevic and Duncan from Coronary Prevention Group, London, UK. The study design, data collection, analyses, interpretation of data, and drafting of the manuscript do not reflect the views and opinions of the funder.

References

1. Rodriguez-Ayllon M, Cadenas-Sánchez C, Estévez-López F, et al. Role of Physical Activity and Sedentary Behavior in the Mental Health of Preschoolers, Children and Adolescents: A Systematic Review and Meta-Analysis. *Sports Med*. 2019;49(9):1383-1410.
2. Pereira S, Reyes AC, Chaves R, et al. Correlates of the Physical Activity Decline during Childhood. *Med Sci Sports Exerc*. 2022;54(12):2129-2137.
3. Biddle SJ, Ciaccioni S, Thomas G, Vergeer I. (2019). Physical activity and mental health in children and adolescents: An updated review of reviews and an analysis of causality. *Psych Sport Exerc*. 2019;42:146-155.
4. Duncan M, Foweather L, Bardid F, Barnett A, Rudd J, O'Brien W et al. Motor Competence Among Children in the United Kingdom and Ireland: An Expert Statement on Behalf of the International Motor Development Research Consortium. *J Mot Learn Dev.* 2022;10(1):7-26.
5. Nevill AM, Duncan MJ, Lahart IM, Sandercock G. Cardiorespiratory fitness and activity explains the obesity-deprivation relationship in children. *Health Promot Int*. 2018;33(3):479-487.
6. James M, Marchant E, Defeyter MA, Woodside J, Brophy S. Impact of school closures on the health and well-being of primary school children in Wales UK: a routine data linkage study using the HAPPEN Survey (2018-2020). *BMJ Open*. 2021;11(10):e051574
7. Howard-Jones AR, Bowen AC, Danchin M, et al. COVID-19 in children: I. Epidemiology, prevention and indirect impacts. *J Paediatr Child Health*. 2022;58(1):39-45.
8. Demetriou Y, Honer O. Physical activity interventions in the school setting: A systematic review. Psych Sport Exerc. 2012;13(2):186–196.
9. Public Health England. What works in schools and colleges to increase physical activity? London: Public Health England; 2022.
10. World Health Organization. Promoting physical activity through schools: Policy Brief. Geneva: World Health Organization;2022.
11. Giles-Corti B, Kelty SF, Zubrick SR, Villanueva KP. Encouraging walking for transport and physical activity in children and adolescents: how important is the built environment?. *Sports Med*. 2009;39(12):995-1009.
12. Neil-Sztramko SE, Caldwell H, Dobbins M. School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6 to 18. *Cochrane Database Syst Rev*. 2021;9(9):CD007651
13. Kibbe DL, Hackett J, Hurley M, et al. Ten Years of TAKE 10!(®): Integrating physical activity with academic concepts in elementary school classrooms. *Prev Med*. 2011;52 Suppl 1:S43-S50.

14. Riley N, Lubans DR, Morgan PJ, Young M. Outcomes and process evaluation of a programme integrating physical activity into the primary school mathematics curriculum: The EASY Minds pilot randomised controlled trial. *J Sci Med Sport*. 2015;18(6):656-661.
15. Innerd, A. L., Azevedo, L. B., & Batterham, A. M. (2019). The effect of a curriculum-based physical activity intervention on accelerometer-assessed physical activity in schoolchildren: A non-randomised mixed methods controlled before-and-after study. *PloS one*, *14*(12), e0225997.
16. Mavilidi MF, Lubans DR, Morgan PJ, et al. Integrating physical activity into the primary school curriculum: rationale and study protocol for the "Thinking while Moving in English" cluster randomized controlled trial. *BMC Public Health*. 2019;19(1):379.
17. Oliver M, Schofield G, McEvoy E. An integrated curriculum approach to increasing habitual physical activity in children: a feasibility study. *J Sch Health*. 2006;76(2):74-79.
18. Duncan MJ, Birch S, Woodfield L. Efficacy of an integrated school curriculum pedometer intervention to enhance physical activity and to reduce weight status in children. Eur Phys Ed Rev. 2012;18(3):396-407.
19. Eyre EL, Cox VM, Birch SL, Duncan MJ. An integrated curriculum approach to increasing habitual physical activity in deprived South Asian children. *Eur J Sport Sci*. 2016;16(3):381-390.
20. Lubans DR, Morgan PJ, Tudor-Locke C. A systematic review of studies using pedometers to promote physical activity among youth. *Prev Med*. 2009;48(4):307-315.
21. Mackenzie K, Williams C. Universal, school-based interventions to promote mental and emotional well-being: what is being done in the UK and does it work? A systematic review. *BMJ Open*. 2018;8(9):e022560.
22. Busch V, de Leeuw JR, de Harder A, Schrijvers AJ. Changing multiple adolescent health behaviors through school-based interventions: a review of the literature. *J Sch Health*. 2013;83(7):514-523.
23. Office for Health Improvement and Disparities. Local Authority Health Profiles, Nuneaton and Bedworth. London: Office for Health Improvement and Disparities. 2022. Available from: https://fingertips.phe.org.uk/ (Accessed, 2/1/2023)
24. Moore CG, Carter RE, Nietert PJ, Stewart PW. Recommendations for planning pilot studies in clinical and translational research. *Clin Transl Sci*. 2011;4(5):332-337.
25. Beets MW, Weaver RG, Ioannidis JPA, et al. Identification and evaluation of risk of generalizability biases in pilot versus efficacy/effectiveness trials: a systematic review and meta-analysis. *Int J Behav Nutr Phys Act*. 2020;17(1):19.

26. Billingham SA, Whitehead AL, Julious SA. An audit of sample sizes for pilot and feasibility trials being undertaken in the United Kingdom registered in the United Kingdom Clinical Research Network database. *BMC Med Res Methodol*. 2013;13:104.
27. Yates T, Haffner SM, Schulte PJ, et al. Association between change in daily ambulatory activity and cardiovascular events in people with impaired glucose tolerance (NAVIGATOR trial): a cohort analysis. *Lancet*. 2014;383(9922):1059-1066.
28. Chandler JL, Brazendale K, Beets MW, Mealing BA. Classification of physical activity intensities using a wrist-worn accelerometer in 8-12-year-old children. *Pediatr Obes*. 2016;11(2):120-127.
29. Migueles JH, Cadenas-Sanchez C, Ekelund U, et al. Accelerometer Data Collection and Processing Criteria to Assess Physical Activity and Other Outcomes: A Systematic Review and Practical Considerations. *Sports Med*. 2017;47(9):1821-1845.
30. Crouter SE, Schneider PL, Bassett DR Jr. Spring-levered versus piezo-electric pedometer accuracy in overweight and obese adults. *Med Sci Sports Exerc*. 2005;37(10):1673-1679.
31. Jackson LV, Thalange NK, Cole TJ. Blood pressure centiles for Great Britain [published correction appears in Arch Dis Child. 2007 Jun;92(6):563]. *Arch Dis Child*. 2007;92(4):298-303.
32. Gillman MW, Cook NR. Blood pressure measurement in childhood epidemiological studies. *Circulation*. 1995;92(4):1049-1057.
33. National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. *Pediatrics*. 2004;114(2 Suppl 4th Report):555-576.
34. Ostchega Y, Nwankwo T, Sorlie PD, Wolz M, Zipf G. Assessing the validity of the Omron HEM-907XL oscillometric blood pressure measurement device in a National Survey environment. *J Clin Hypertens*. 2010;12(1):22-28.
35. Hosking J, Metcalf BS, Jeffery AN, Voss LD, Wilkin TJ. Validation of foot-to-foot bioelectrical impedance analysis with dual-energy X-ray absorptiometry in the assessment of body composition in young children: the EarlyBird cohort. *Br J Nutr*. 2006;96(6):1163-1168.
36. Tyrrell VJ, Richards G, Hofman P, Gillies GF, Robinson E, Cutfield WS. Foot-to-foot bioelectrical impedance analysis: a valuable tool for the measurement of body composition in children. *Int J Obes Relat Metab Disord*. 2001;25(2):273-278.
37. Ulrich DA. *Test of Gross Motor Development*, 3rd ed.; Pro-Ed: Austin, TX, USA, 2013.
38. Barnett LM, Minto C, Lander N, Hardy LL. Interrater reliability assessment using the Test of Gross Motor Development-2. *J Sci Med Sport*. 2014;17(6):667-670.

39. Jones RA, Okely AD, Caputi P, Cliff DP. Perceived and actual competence among overweight and non-overweight children. *J Sci Med Sport*. 2010;13(6):589-596.
40. Angold A, Costello EJ, Messer SC, Pickles A, Winder F, Silver D. Development of a short questionnaire for use in epidemiological studies of depression in children and adolescence. *Int J Methods Psychiatr Res. 1995;*5:237- 249.
41. Cole DA, Goodman SH, Garber J, et al. Validating parent and child forms of the Parent Perception Inventory. *Psychol Assess*. 2018;30(8):1065-1081.
42. Sharp C, Goodyer IM, Croudace TJ. The Short Mood and Feelings Questionnaire (SMFQ): a unidimensional item response theory and categorical data factor analysis of self-report ratings from a community sample of 7-through 11-year-old children. *J Abnorm Child Psychol*. 2006;34(3):379-391.
43. Barnett LM, Ridgers ND, Zask A, Salmon J. Face validity and reliability of a pictorial instrument for assessing fundamental movement skill perceived competence in young children. *J Sci Med Sport*. 2015;18(1):98-102.
44. Duncan MJ, Jones V, O'Brien W, Barnett LM, Eyre ELJ. Self-Perceived and Actual Motor Competence in Young British Children. *Percept Mot Skills*. 2018;125(2):251-264.
45. McNamara C. General guidelines for conducting interviews http://managementhelp.org/evaluatn/intrview.htm; 2009.
46. Braun V, Clarke V. Reflecting on reflexive thematic analysis. *Qual Res Sport, Exerc Hlth.* 2019;11(4);589-597.
47. Cohen D, Crabtree B. Qualitative Research Guidelines Project Retrieved 11, 2021, from http://www.qualres.org/homesemi-3629.html; 2006.
48. O'Connell NS, Dai L, Jiang Y, et al. Methods for Analysis of Pre-Post Data in Clinical Research: A Comparison of Five Common Methods. *J Biom Biostat*. 2017;8(1):1-8.
49. Clifton L, Clifton DA. The correlation between baseline score and post-intervention score, and its implications for statistical analysis. *Trials*. 2019;20(1):43.
50. Weissgerber TL, Milic NM, Winham SJ, Garovic VD. Beyond bar and line graphs: time for a new data presentation paradigm. *PLoS Biol*. 2015;13(4):e1002128
51. Tudor-Locke C, Craig CL, Beets MW, et al. How many steps/day are enough? for children and adolescents. *Int J Behav Nutr Phys Act*. 2011;8:78.
52. Michie S, van Stralen MM, West R. The behaviour change wheel: A new method for characterising and designing behaviour change interventions. *Implement Sci.* 2011;6(1):42.

53. Eyre ELJ, Adeyemi LJ, Cook K, Noon M, Tallis J, Duncan M. Barriers and Facilitators to Physical Activity and FMS in Children Living in Deprived Areas in the UK: Qualitative Study. *Int J Environ Res Public Health*. 2022;19(3):1717

54. Adeyemi-Walker LJ, Duncan M, Tallis J, Eyre E. Fundamental Motor Skills of Children in Deprived Areas of England: A Focus on Age, Gender and Ethnicity. *Children (Basel)*. 2018;5(8):110.

55. Eyre EL, Duncan MJ, Birch SL, Cox VM. Low socio-economic environmental determinants of children's physical activity in Coventry, UK: A Qualitative study in parents. *Prev Med Rep*. 2014;1:32-42.

56. Eyre EL, Duncan MJ, Birch SL, Cox V, Blackett M. Physical activity patterns of ethnic children from low socio-economic environments within the UK. *J Sports Sci*. 2015;33(3):232-242.

57. Bronfenbrenner U. Toward an experimental ecology of human development. Am Psychol. 1977;32(7):513–531.

58. Sallis JF, Owen N, Fisher EB. Ecological Models of Health Behavior. In K. Glanz, B. K. Rimer, & K. Viswanath (Eds.), Health Behavior and Health Education: Theory, Research, and Practice (4th ed., pp. 465-486). San Francisco, CA: Jossey-Bass. 2008.

Table 1. Mean ± SD and 95% Confidence Intervals for primary and secondary outcome variables at pre and post for intervention (INT) and control (CON) groups

Variables	**Pre-Post**	**INT** Mean±SD [95%CI]	**CON** Mean±SD [95%CI]
Sedentary Time (mins)	**Pre-intervention**	82.2± 62.0 [58.2-106.2]	93.5± 108.2 [39.7-147.4]
	Post-intervention	118.9± 56.4 [97.1-140.8]	139.4± 121.3 [79.6-200.2]
Light PA Time (mins)	**Pre-intervention**	159.5± 43.9 [142.9-176.5]	193.3± 78.9 [154.0-232.5]
	Post-intervention	141.5± 51.5 [121.6-161.5]	167.8± 98.4 [118.9-216.8]
Moderate PA Time (mins)	**Pre-intervention**	63.2± 25.8 [53.2-73.2]	73.2± 33.9 [56.3-90.1]
	Post-intervention	62.3± 20.9 [54.4-70.3]	52.2± 33.2 [35.6-68.7]
Vigorous PA Time (mins)	**Pre-intervention**	1.93± 10.2 [53.2-73.2]	0± 0 [0-0]
	Post-intervention	0± 0 [0-0]	0± 0 [0-0]
SBP (mmHg)	**Pre-intervention**	90.2± 12.4 [85.4-95.0]	83.7± 18.7 [76.5-91.1]
	Post-intervention	81.3± 12.7 [76.7-85.8]	80.2± 12.1 [75.8-84.6]
DBP (mmHg)	**Pre-intervention**	61.6± 8.4 [58.4-64.9]	57.8± 8.1 [54.8-64.7]
	Post-intervention	59.2± 13.5 [54.0-64.5]	58.8± 7.7 [56.1-61.6]
Body fatness (%)	**Pre-intervention**	17.9± 5.6 [15.7-20.1]	17.8± 3.9 [16.3-19.2]
	Post-intervention	17.2± 4.5 [15.4-19.0]	18.1± 3.6 [16.8-19.4]
Motor Skills (0-40)	**Pre-intervention**	19.1± 3.5 [17.8-20.6]	19.9± 4.7 [18.2-21.7]
	Post-intervention	19.5± 3.2 [18.2-20.8]	20.4± 3.9 [18.9-21.8]
Perceived Physical Competence (4-16)	**Pre-intervention**	13.2± 3.2 [12.0-14.5]	13.5± 2.7 [12.5-14.5]
	Post-intervention	14.0± 2.3 [13.1-14.9]	13.6± 2.3 [12.8-14.5]
SMFQ (0-26)	**Pre-intervention**	5.2± 3.1 [4.0-6.4]	4.1± 3.5 [2.8-5.3]
	Post-intervention	3.0± 1.7 [2.3-3.7]	3.6± 2.7 [2.5-4.5]

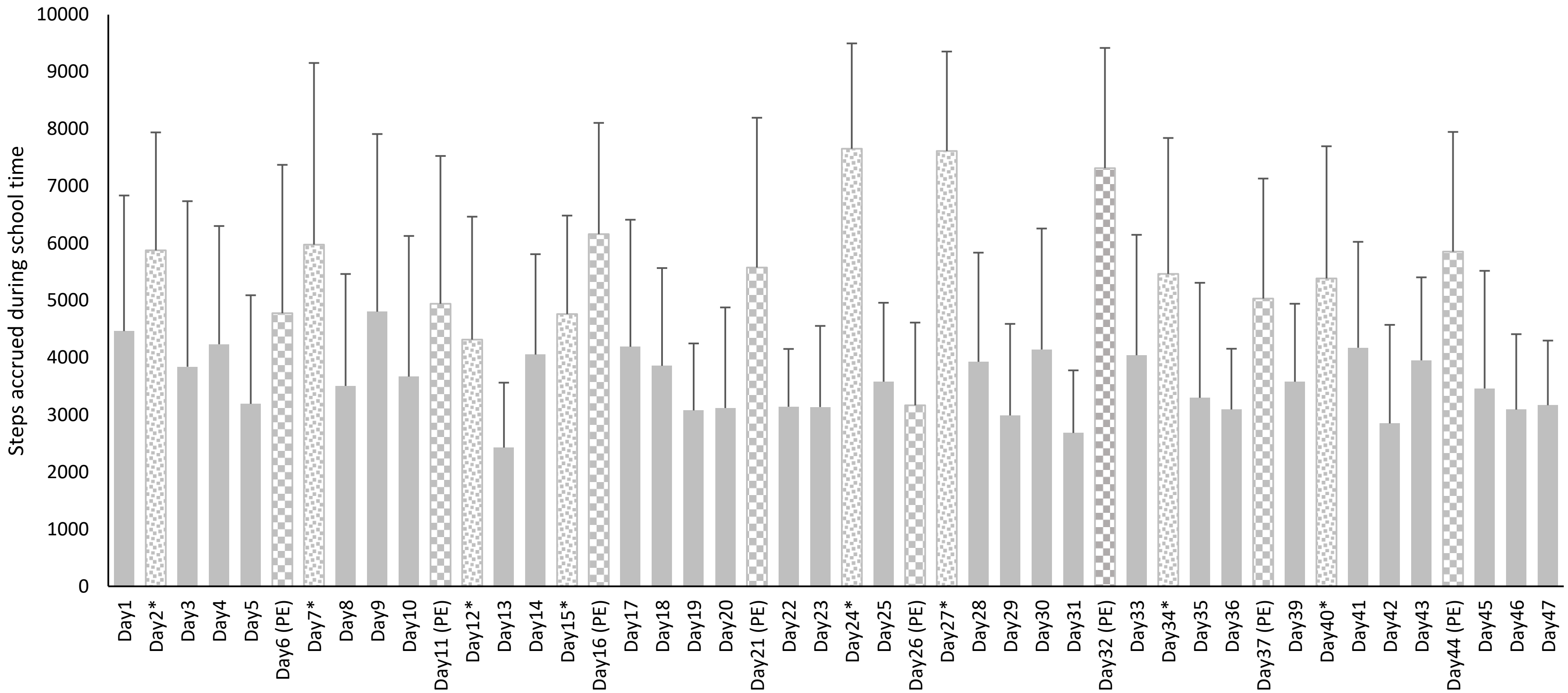

Figure 1. Mean ± SD of steps accrued during each day of the intervention period identifying days when physically active integrated curriculum activities took place (Dotted bars) and days when statutory PE took place (Chequered bars).

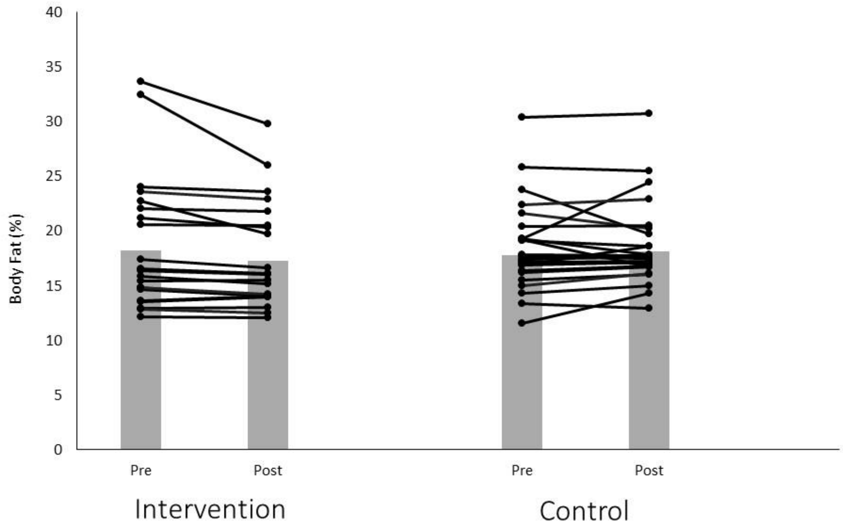

Figure 2. Mean and individual data for percent body fat, pre and post for intervention and control groups

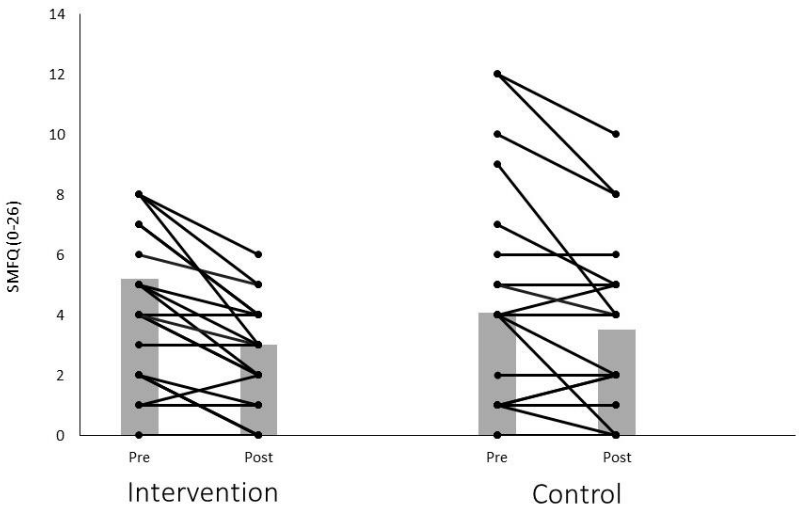

Figure 3. Mean and individual data for Short Mood and Feeling Questionnaire (0-26, lower scores = better mental well-being), pre and post for intervention and control groups

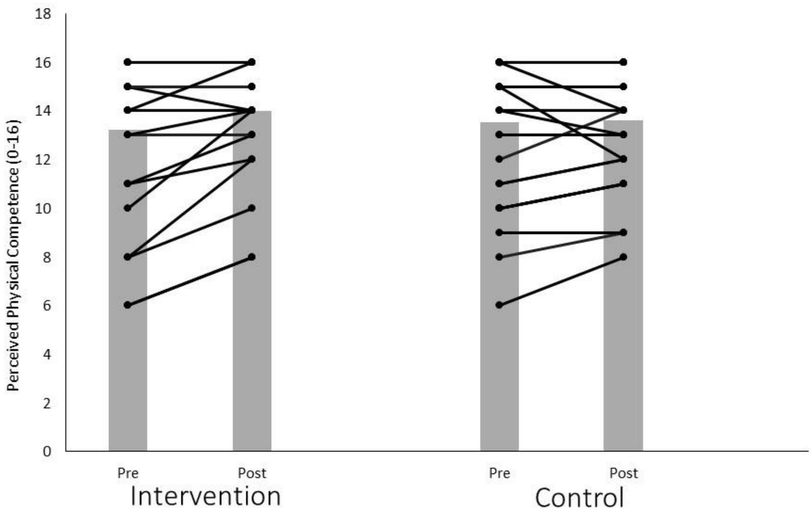

Figure 4. Mean and individual data for Perceived Movement Competence (0-16, higher scores = more positive perception of own physical ability), pre and post for intervention and control groups

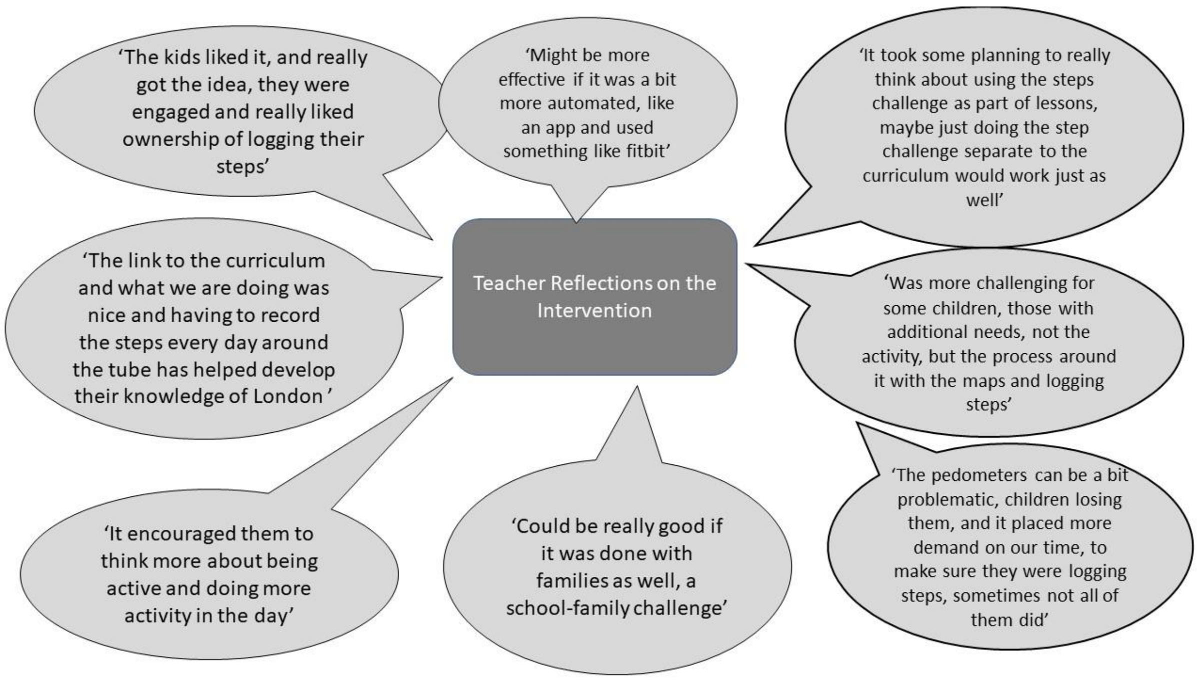

Figure 5. Teacher reflections on the intervention.