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Camden active spaces: Does the construction of active school playgrounds influence children's physical activity levels? A longitudinal quasi-experiment protocol

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ABSTRACT

Introduction: Physical activity is essential for every facet of children's health. However, physical activity levels in British children are low. The school environment is a promising setting to increase children's physical activity but limited empirical evidence exists on how a change in the outdoor physical school environment influences physical activity behaviour. The London Borough of Camden is redesigning seven existing school playgrounds to engage children to become more physically active. The primary aim of this project is to evaluate the impact of the redesigned playgrounds on children's physical activity, well-being and physical function/fitness.

Method and analysis: This project will use a longitudinal quasi-experimental design. Seven experimental schools and one control school will take part. One baseline data collection session and two follow-ups will be carried out. Between baseline and follow-up, the experimental school playgrounds will be redesigned. At baseline, a series of fitness tests, anthropometric and questionnaire measurements, and 7-day objective physical activity monitoring (Actigraph accelerometer) will be carried out on children (aged 5–16 years). This will be repeated at follow-up. Changes in overall physical activity levels and levels during different times of the day (eg, school breaks) will be examined. Multilevel regression modelling will be used to analyse the data.

Ethics and dissemination: The results of this study will be disseminated through peer-review publications and scientific presentations. Ethical approval was obtained through the University College London Research Ethics Committee (Reference number: 4400/002).

INTRODUCTION

Physical activity is essential for every facet of children's (aged 5–16 years) health. For example, higher levels of physical activity in children are associated with more favourable cardiovascular disease risk factors, whereas excessive levels of sedentary behaviour have the reverse effect.[1 2] Physical activity can also benefit psychological health by aiding in the prevention of anxiety and depressive symptoms and contributing to the improvement of self-esteem.[3] Importantly, rather than detracting from learning, more physical activity and breaks from sitting in school are thought to enhance cognitive function and academic performance.[4] It is also more likely that active children will become active adults, since some tracking of physical activity behaviour has been observed from childhood to adulthood.[5] However, in westernised countries, current levels of physical activity in children are low as there are increasing opportunities to participate in sedentary activities.[6 7] For example, it is recommended that children engage in physical activity of moderate intensity for at least 1 h a day to maintain good health.[8] However, just 24% of British girls and 32% of boys achieve this recommendation.[7] Physical inactivity is estimated to cost the NHS approximately £8 billion per year in healthcare costs alone.[8] Encouraging physically active lifestyles in children is therefore crucial in nurturing a healthy future generation of adults.

A recent meta-analysis found that the effects of interventions to increase physical activity in children have been, at best, modest and concluded that alternative approaches are required.[9] In the UK, children spend approximately 60% of their weekday in school where physical activity levels, particularly in girls, are low.[10 11] Environments both facilitate and provide the arena for physical activity.[12] Interventions

that target the school environment may offer great opportunity to increase physical activity levels. However, there is little robust empirical evidence concerning the effect of changing the physical environment on activity levels in children. Emerging data have suggested that a positive perception of the school play environment was associated with higher levels of moderate–vigorous physical activity (MVPA) during playtime.[13] Moreover, the number of permanent play facilities in school playgrounds has been found to be associated with higher physical activity levels.[14] A recent review[15] on the value of playgrounds for children's physical activity identified 13 experimental studies, which have produced mixed findings, most likely owing to differences in intervention design. For example, the review identified that reducing playground density increased physical activity levels, but the provision of play equipment produced mixed effects, whereas no effects were found on the provision of playground markings and promotion of physical activity by teachers. Just one study investigated the impact of 'major' playground reconstruction on children's physical activity behaviour[16] and concluded that renovated schoolyards to promote physical activity may increase the number of children who are physically active and reduce sedentary behaviours. However, physical activity data were collected using only direct observation during the school day. This limits the ability to examine carry-over effects outside the school environment (ie, at weekends and during evenings). Taken together, the emerging evidence suggests that the physical environment could play an important role in children's physical activity behaviour, but more robust evidence is required.

Increasing physical activity levels is well established as a way to improve fitness and health outcomes in young people. Strong *et al*'s[1] review identified 17 experimental studies that aimed to increase levels of physical activity, and these all found improvements in aerobic fitness. Two experimental studies implemented programmes of moderately intense exercise 30–60 min in duration, 3–7 days/week, and this led to a reduction in total body adiposity in overweight young people. Interestingly, the review also identified three longitudinal and two experimental studies in young people that showed that physical activity or strength training improved muscular strength and endurance. It is plausible to assume that an increase in movement and a decrease in sedentary behaviour may result in an increase in hamstring flexibility. This is important as maintaining hamstring flexibility may prevent acute and chronic musculoskeletal injuries.[17] There is also evidence that physical activity is associated with scores on a scale (The Strengths and Difficulties Questionnaire) measuring mental well-being (eg, happiness, behaviour, concentration, self-esteem, etc).[18] On this basis, we hypothesise that a change in the physical school playground environment that increases levels of physical activity or reduces sedentary behaviour should subsequently improve fitness and health outcomes.

A recent study found that engaging in 40% of moderate-intensity physical activity during school playtime equated to 34 min of daily MVPA.[19] This exceeds the *minimum* recommendation of 30 min of at least moderate-intensity physical activity for children's good health.[20] It has been suggested that this guideline is a realistic target for children to achieve during school playtime,[21] especially if a playground has been modified to encourage physical activity.

SETTING

Camden Borough Council is redesigning seven existing school playgrounds (five primary schools and two secondary schools), which are thought not to be conducive to physical activity/active play, with exciting bespoke features to engage children to become more active. Each school will receive a unique playground design, for example, displayed in figure 1. Example features include new Astroturf games pitches, climbing frames, trampolines, monkey bars and outdoor gyms, which have been designed based on themes (eg, ancient ruins, volcanoes and clouds) emerging from qualitative work with children and teachers in each school. The research team did not carry out the qualitative work, nor did it provide input into the design of the playgrounds. The qualitative work and the design of the playgrounds were carried out by two private organisations specialising in playground design. Camden Council's underlying goal is to encourage participation by creating opportunities for physical activity outside of traditional sports or team competition. This presents a unique opportunity to evaluate the impact of these structures on children's physical activity, health and well-being outcomes while addressing previous limitations in the literature (ie, collecting activity only in school).

We hypothesise that the new playgrounds will increase young people's time spent in light physical activity and MVPA and reduce sedentary behaviour during break time, and consequently improve levels of general fitness (eg, grip and leg strength, peak flow and adiposity).

AIMS

The *Camden Active Spaces* project consists of two key elements: (1) redesign of the school playgrounds and (2) evaluation of the hypothesised benefits. In the present paper, we focus on the evaluation only. Thus, the primary aim of this project is to evaluate the impact of the redesigned playgrounds on children's physical activity, well-being and physical function/fitness.

METHOD AND ANALYSES

The evaluation of *Camden Active Spaces* will use a longitudinal quasi-experimental design. Baseline data collection will take place in the Spring/Summer term 2014, follow-up I data collection will take place during the Autumn term 2014, and follow-up II during the Summer

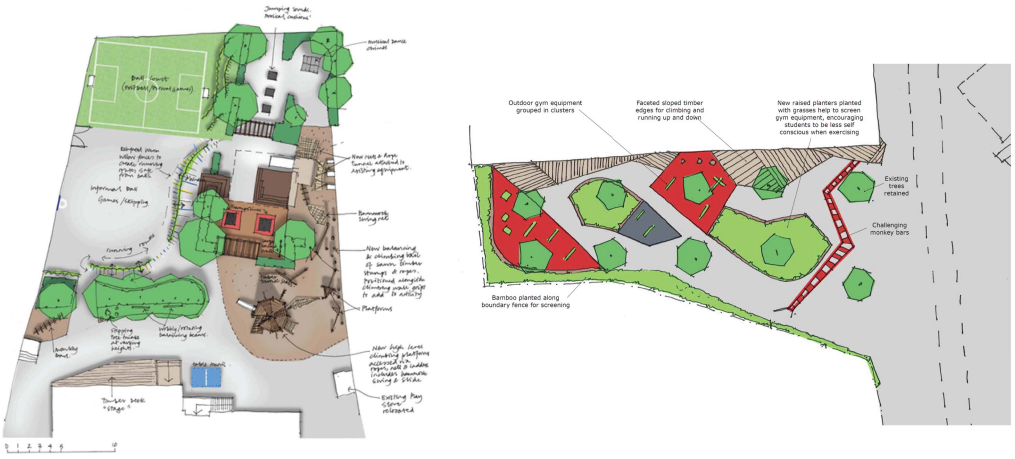

Figure 1 Example of new playground designs.

term of 2015 (see figure 2). Between baseline and follow-up I (school summer holidays), the school playgrounds will be redesigned. A second follow-up will allow us to investigate if short-term effects of the intervention (if they exist) are sustained over a longer period. This evaluation has been funded by the Economic and Social Research Council, UK (ES/M003795/1), while the core project (playground redesign) has been funded by the Camden Clinical Commissioning Group and London Borough of Camden.

Inclusion criteria

School inclusion criteria

Seven schools located in the London Borough of Camden have been selected to receive the redesigned playgrounds and all of them have agreed to take part in the study.

In addition to the seven experimental schools, one control school will be recruited into the study. This school will be located in the London Borough of Camden and it will not be receiving a new playground design; moreover, it will not differ from experimental schools based on student demographics or school policy. Owing to resource constraints, it is only feasible to collect data from a single control school. The authors acknowledge that an equal number of controls in experimental schools would allow for a more robust experimental design.

Participant inclusion criteria

We aim to randomly select approximately 100 children (see below power calculation) evenly distributed across school-year groups (aged 5–11 years in primary school and aged 11–16 years in secondary school) from each of the eight schools (total sample size 800). Children aged 17–18 years or any school leavers in 2014 will not be asked to participate in the current project, owing to time table restrictions due to final examinations and potential loss to follow-up. Students whose parents have not opted them out of the study will be eligible to participate (see section Ethics and Dissemination for details on obtaining consent).

Recruitment

The seven schools who will be receiving the redesigned playgrounds have previously been recruited into the

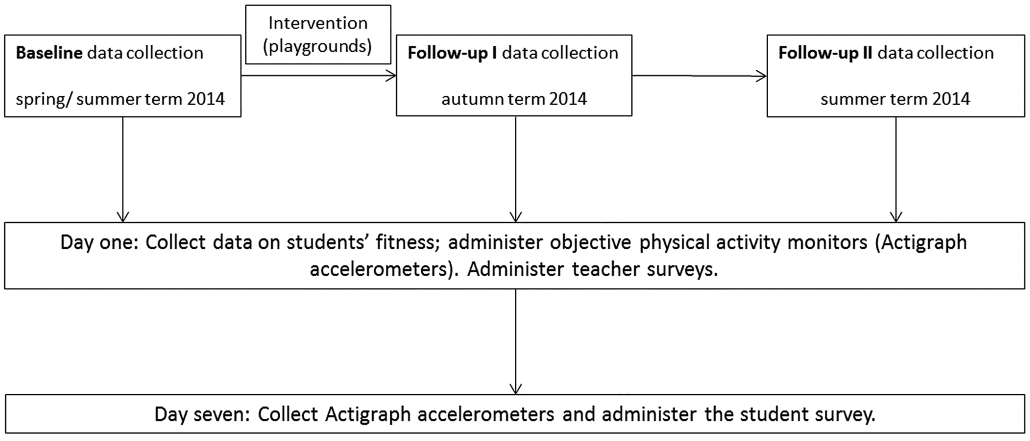

Figure 2 Overview of the study design.

study by Camden Borough Council. To recruit children into the study, presentations will be given during assemblies to each year group within each school. The presentations will disseminate information on *Camden Active Spaces*, what would be involved if children were to take part in the study and benefits of the study to children and the school. At the end of presentations, children will be given participant study information sheets. In order to make parents aware of the study, a parent information sheet will be emailed to all parents (translated into different languages where required), posted on the school webpage, in addition to hard copies being made available at the school. In an attempt to maximise response rates and adherence to protocol, each child who completes the wear protocol will be awarded a 1-month free swimming voucher and entered into a prize draw to win an iPod Touch (one iPod Touch will be awarded per school). All schools taking part in the study will be entered into a separate prize draw to win one of two Nintendo Wiis.

Procedures

Data collection procedures will take place over a period of 12 months. A team of trained researchers will collect data from each school on a date and time that is convenient for the school. Children will be invited to take part in data collection. Data collection sessions will last approximately 30 min. A series of fitness tests and anthropometric measurements will be carried out on children, in an appropriate room in the school (eg, sports or assembly hall). Once fitness tests and anthropometric measurements have been completed, objective devices (accelerometers) will be given to children to monitor their physical activity behaviour. Between 4 and 7 days of accelerometer data are needed to provide a reliable estimate of habitual physical activity.[22] Thus, participants will be asked to wear objective devices for seven consecutive days. On day 7, participants will return the device to research staff at the school where they will then complete a questionnaire on their physical activity behaviour. This exact process will be repeated at follow-ups I and II.

Measurement and instruments

Accelerometer

It is now recognised that accelerometers provide the most reliable and valid measurement of activity in children[16] and are considered the gold standard approach. These wearable motion sensors measure movement across three dimensions, thus providing minute-by-minute time-stamped data on activity intensity, duration and patterns across the day. Objective physical activity monitoring has been successfully used in similar study settings to the present project.[14 23 24]

The present evaluation will use the Actigraph GT3X accelerometer. This device is validated and has been used in other studies with primary and high school children (see eg, http://www.iconnect.co.uk and http://www.cedar.iph.cam.ac.uk/research/directory/speedy/). The Actigraph GT3X is worn on a belt around the waist with the device itself positioned above the right hip either over or under clothing. We will employ a sampling frequency of 30 Hz. Children will be asked to wear the device during waking hours every day for seven consecutive days, but not during water-based activities or sleep.

Fitness tests

A series of fitness tests will be carried out, following Standard Operating Procedure Forms, on all children taking part in the study. Four fitness tests will be carried out to measure aspects of general fitness: participants will be asked to perform the hand-held Dynamometer test to assess grip strength, the standing horizontal jump test to assess leg power, the peak flow test to assess lung function and the sit-and-reach test to assess flexibility. Participants' weight and body composition will be measured using the Tanita SC-330 Body Composition Analyser (Tanita Inc, Illinois, USA) and height will be measured using the Leicester Height Measure, from which body mass index (BMI) will be calculated in kg/m^2. These tests have been extensively used in previous cohort studies of young people (eg, http://www.chasestudy.ac.uk/study-measurement) and have shown good validity and reliability in young people across broad age groups (http://www.chasestudy.ac.uk/study-measurement).[25–27]

Questionnaires

All children taking part in the study will be asked to complete a questionnaire. The questionnaire will take approximately 10 min to complete and includes questions on standard demographics and physical activity, as well as potentially important correlates of physical activity. Teaching assistants and research staff will assist all children in completing questionnaires.

The Girls Health Enrichment Multi-Studies (GEMS) physical activity survey has been embedded within the questionnaire to give a subjective measure of physical activity and to provide an understanding of which specific physical activity behaviours are influenced by the playground redesign, if any. GEMS has validity and reliability equivalent to other self-report measures of physical activity[28] and was deemed suitable for both primary and high school boys and girls by those who designed the present study, owing to its simplicity. The questionnaire also includes items on travel mode (as used in the iConnect Study; http://www.iconnect.co.uk).

Teachers will be asked to complete the validated Strengths and Difficulties questionnaire[29]; this questionnaire provides a measure of children's behaviour, mental health, engagement and well-being and takes approximately 5 min to complete per child.

Each school has one head teacher. Head teachers (n=8) will be asked to complete a questionnaire to allow for an understanding of differences between schools on 'playground policy'. Questions include, "During what type of weather are children not allowed to go outside

during scheduled breaks (ie, rain/ snow)?" "Are any sections of the current playground out of use during bad weather (ie, school field when raining), if yes please specify?" "When children cannot go outside on scheduled breaks, owing to bad weather, where do they spend their break?" and "Are there any current initiatives/programs to promote physical activity and/or healthy lifestyles in your school, if yes please specify?" Head teachers will be asked to complete an identical survey at follow-up to allow for the assessment of changes in "playground policy" between each time point.

ANALYSIS

Outcome

The primary outcome for this study will be change in average daily time spent in MVPA as recorded by the Actigraph accelerometer. In addition, the study has been designed to collect the following secondary outcomes using participant questionnaires and objective measures: (1) change in average daily time spent sedentary; (2) change in average daily time spent in light and vigorous activity at different times of the day (playtimes at school, leisure time at home); (3) change in peak flow, sit-and-reach, grip strength, standing horizontal jump and BMI/body composition and (4) change in Strength and Difficulties scores.

Quantitative analysis

Raw data files will be extracted from each Actigraph device and processed using bespoke software (Actilife) to quantify a range of features that will directly contribute to the determination of active and sedentary time. We intend to follow methods used in the International Children's Accelerometry Database study that incorporated children aged 4–18 years.[2] In brief, data files will be reintegrated to a 60 s epoch and non-wear time defined as 60 min of consecutive zeros, allowing for 2 min of non-zero interruptions. All children with at least 1 day with at least 500 min of measured monitor wear time between 7:00 and midnight will be included. Total physical activity will be expressed as total counts, including sedentary minutes, divided by measured time per day (counts/min, cpm). Time spent sedentary will be defined as all minutes showing less than 100 cpm and MVPA time as minutes showing more than 3000 cpm. Multilevel modelling will be used to analyse the data. This approach offers several advantages over simple regression models. We will be able to model changes in activity over the three assessment periods accounting for the interindividual as well as intraindividual differences.

Sample size

A previous school-based intervention to examine the effects of changes in playground structure on physical activity[23] demonstrated a small effect size (d=0.10). Thus, based on these data, a sample size of N=458 would provide us with 80% power at 5% significance level to detect small differences in moderate intensity physical activity using a repeated measures design (calculated using G-Power). We will aim to recruit 100 children from each school to allow for dropout and incomplete Actigraph data.

LIMITATIONS

It is not possible to carry out a multicentre, cluster randomised controlled trial. The key limitations of this study include a quasi-experimental design with non-randomly selected control participants and the recruitment of one control school.

ETHICAL CONSIDERATION AND DISSEMINATION

First, head teachers from each school will be asked to provide explicit written consent for their schools and schoolchildren to take part in the study. Next, if parents (of primary and secondary schoolchildren) do not want their child(ren) to take part in the study, they will be given the option to 'opt-out' their child(ren); instructions to parents on how to opt-out their child(ren) are provided in the parent study information sheet. Prior to data collection, all high school (not primary school) children will be asked to provide explicit written assent.

The findings from this study will be disseminated to academic researchers and to policymakers through several mechanisms. First, we will employ the usual avenues for dissemination of academic research, including conference presentations and journal articles. Second, we will disseminate this research via social media outlets such as the University College London—Physical Activity Research Group Twitter account. Third, with Camden Council, we will include this physical activity study within the regular programme of briefings that are presented to government departments interested in physical activity, including the Department of Health, the Department for Communities and Local Government, etc.

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Competing interests None.

Patient consent Obtained.

Ethics approval Ethical approval was granted by the University College London Research Ethics Committee (4400/002).

Provenance and peer review Not commissioned; externally peer reviewed.

REFERENCES

1. Strong WB, Malina RM, Blimkie CJR, *et al*. Evidence based physical activity for school-age youth. *J Pediatr* 2005;146:732–37.
2. Ekelund U, Luan JA, Sherar LB, *et al*. Moderate to vigorous physical activity and sedentary time and cardiometabolic risk factors in children and adolescents. *JAMA* 2012;307:704–12.
3. Centre for Diseases and Control Prevention. *Physical activity and health*. Atlanta, 2013.
4. Lees C, Hopkins J. Effect of aerobic exercise on cognition, academic achievement, and psychosocial function in children: a systematic review of randomized control trials. *Prev Chronic Dis* 2013;10:E174.
5. Telama R, Yang X, Viikari J, *et al*. Physical activity from childhood to adulthood: a 21-year tracking study. *Am J Prev Med* 2005;28:267–73.
6. Griffiths LJ, Cortina-Borja M, Sera F, *et al*. How active are our children? Findings from the Millennium Cohort Study. *BMJ Open* 2013;3:e002893.
7. Joint Health Surveys Unit. *The Health Survey for England 2008. The Information Centre for Health and Social Care*. Leeds, 2009. http://www.ic.nhs.uk/pubs/hse08physicalactivity
8. Department of Health. Start Active Stay Active: a report on physical activity for health from the four home countries' Chief Medical Officers (UK). July 2011.
9. Metcalf B, Henley W, Wilkin T. Effectiveness of intervention on physical activity of children: systematic review and meta-analysis of controlled trials with objectively measured outcomes. *Br J Sports Med* 2013;47:226–6.
10. Smith L, Sahlqvist S, Ogilvie D, *et al*. Is active travel to non-school destinations associated with physical activity in primary school children? *Prev Med* 2012;54:224–8.
11. Nettlefold L, Mckay HA, Warburton DER. The challenge of low physical activity during the school day: at recess, lunch and in physical education. *Br J Sports Med* 2011;45:813–19.
12. Fisher A, van Jaarsveld CHM, Llewellyn CH, *et al*. Environmental influences on children's physical activity: quantitative estimates using a twin design. *PLoS ONE* 2010;5:e10110.
13. Yildirim M, Arundell L, Cerin E, *et al*. What helps children to move more at school recess and lunchtime? Mid-intervention results from Transform-Us! cluster-randomised controlled trial. *Br J Sports Med* 2014;48:271–7.
14. Taylor R, Farmer V, Cameron S, *et al*. School playgrounds and physical activity policies as predictors of school and home activity. *Int Jr Behav Nutr Phys Act* 2011;8:38.
15. Broekhuizen K, Scholten A, de Vries S. The value of (pre)school playgrounds for children's physical activity level: a systematic review. *Int Jr Behav Nutr Phys Act* 2014;11:59.
16. Brink L, Nigg C, Lampe S, *et al*. Influence of schoolyard renovation on children's physical activity: the learning landscape Program. *Res Pract* 2010;100:1672–78.
17. ACSM. *Guidelines for exercise testing and perceription*. 6th edn. Baltimore: Lippincott, Williams and Wilkins, 2000:85–8.
18. Brodersen N, Steptoe A, Williamson S, *et al*. Sociodemographic, developmental, environmental, and psychological correlates of physical activity and sedentary behaviour at age 11 to 12. *Ann Behav Med* 2005;29:2–11.
19. Ridgers N, Stratton G, Fairclough S. Assessing physical activity during recess using accelerometry. *Prev Med* 2005;41:102–7.
20. Biddle S, Sallis J, Cavill N, eds. *Young and active: physical activity guidelines for young people in the UK*. London: Health Education Authority, 1998.
21. Ridgers N, Stratton G, Fairclough S. Physical activity levels of children during school play time. *Sports Med* 2006;36:359–71.
22. Corder K, Brage S, Ekelund U. Accelerometers and pedometers: methodology and clinical application. *Curr Opin Clin Nutr* 2007;10:597–603.
23. Blaes A, Ridgers ND, Aucouturier J, *et al*. Effects of a playground marking intervention on school recess physical activity in French children. *Prev Med* 2013;57:580–4.
24. Smith L, Sahlqvist S, Ogilvie D, *et al*. Is a change in mode of travel to school associated with a change in overall physical activity levels in children? Longitudinal results from the SPEEDY study. *Int J Behav Nutr Phy* 2012;9:134.
25. Ruiz J, Castro-Pinero J, Espana-Romero V, *et al*. Field-based fitness assessment in young people: the ALPHA health-related fitness test battery for children and adolescent. *Br J Sports Med* 2011;45:518–25.
26. Ortega F, Artero E, Ruiz J, *et al*. Reliability of health-related physical fitness tests in European adolsecents. The HELENA Study. *Int J Obes (Lond)* 2008;32:49–57.
27. Kirkby J, Welsh L, Lums S, *et al*. The EPICure study: comparison of pediatric spirometry in community and laboratory settings. *Pediatr Pulmonol* 2008;43:1233–41.
28. Treuth MS, Sherwood NE, Butte NF, *et al*. Validity and reliability of activity measures in African–American girls for GEMS. *Med Sci Sports Exerc* 2003;35:532–9.
29. Goodman R. Psychometric properties of the strengths and difficulties questionnaire. *J Am Acad Child Adolesc Psychiatry* 2001;40:1337–45.

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