PLAYGROUNDS

PLAY HARD, LEARN EASY

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CONTENTS

CHAPTER 1
GENERAL INTRODUCTION

Is it possible to change the playground environment in order for children to become physically more active? That was the starting question of the study that eventually led to this thesis. In the process we developed a parallel and equally interesting question: "Would increased physical activity levels during recess positively influence selective attention during class?"
The subtitle ('Play hard, Learn easy') combines these two questions answered in this thesis. In the first part, the PLAYgrounds programme – a playground programme for primary school children – is described and evaluated. The second part of the thesis focuses on possible acute effects of physical activity on selective attention.

BACKGROUND

National and international studies have shown that sedentary lifestyle is a major public health problem (1), also for children. Worldwide, 31.1% of adults are physically inactive, a proportion that is even higher in Europe (34.8%) (2). European studies have shown that only 4.6% of girls and 16.8% of boys meet the guideline (3) of a minimum of 60 minutes of at least moderate intensity PA per day, on each day of the week (4). Dutch studies have shown comparable data; 10% of the children between the ages of 4 and 12 years old meet the guideline (5), while in areas with a relatively large part of the population consisting of children of immigrant origin with a low socioeconomic status, only 3-4% of the children meet the guideline (6). Although the percentage of children between the ages of 12 and 16 years old who meet the guideline varies around 20-30% (7), the proportion of children who are physically inactive is alarmingly high.

The figures above are of concern; physical inactivity is strongly associated with obesity, likewise in children (8). In the total Dutch population, 15.0% of the children between the ages of 4 to 19 years old is overweight, with 6% of the children being obese (9). In the lower socioeconomic urban areas, the percentage of children who are overweight is even higher. For example in Amsterdam New-West, where the data for this thesis was gathered, 31.9% of the children are overweight (9).
Children with obesity have a higher risk of a cardiovascular disease, such as high cholesterol or high blood pressure, for bone and joint problems, sleep apnea, and social and psychological problems such as stigmatization and poor self-esteem (10).
Additionally, children and adolescents who are obese are also likely to be obese as adults (11). Obese adults are at increased risk of chronic health problems such as heart disease, type 2 diabetes, stroke, and osteoarthritis (12). In addition, overweight and obesity are associated with increased risk for many types of cancer (13) and the indirect effect of adult obesity in terms of disability to work is substantial (14).
In conclusion, inactivity leads to obesity during childhood, which tracks into adulthood, with major health and societal consequences. However, whether physical activity levels persist within individuals with time is inconclusive. Tracking coefficients are high in short periods but lower with time, and attenuate through the life course (15).

PHYSICAL INACTIVITY

Nevertheless, physical inactivity is a major risk factor for health problems, independent from obesity. Lee and colleagues (16) estimated that physical inactivity causes 6-10% of all deaths from major non-communicable diseases (coronary heart disease, type 2 diabetes, and breast and colon cancers). Furthermore, they showed that inactivity caused more than 5.3 of the 57 million deaths that occurred worldwide in 2008, which equates with death from tobacco use (17).

In addition, adults who do meet the guidelines of 30 minutes or more of at least moderate intensity physical activity per day, but who also are sedentary (i.e. sitting; <1.5 METs) during the rest of the day (such as watching television, working behind a desk) have an increased risk for premature mortality. There are clear associations between levels of sitting and mortality risk in both physically inactive and active men and women (18), which means that the relation between sedentary behaviour and cardiovascular disease mortality is independent of physical activity levels.

PHYSICAL FITNESS

Parallel to the decreased levels of daily physical activity, physical fitness levels in children have decreased over the past decades (19-22). Several studies in adults have shown that low aerobic fitness carries a significantly larger health risk than obesity per se (23, 24). It might even be unhealthier to be slim but unfit, instead of fat and fit (25). In children comparable observations were made; a longitudinal study in children who were followed from 13 to 36 years old, showed that a greater decrease in cardiopulmonary fitness from adolescence to adulthood was also a characteristic of individuals with the metabolic syndrome, and this was independent of the increase in body fat (26).

NEUROMOTOR SKILLS

In addition to the alarming physical inactivity trend in children, the number of sport injuries in children has increased. Over a period of 6 years (2006-2011) the percentage of sport injuries in children between the ages of 9 and 12 years old has increased by 50% (27). According to the authors, a main cause could be a decrease in daily physical activity and as a result a decrease in neuromotor skills (28). Children who are insufficiently physically active show poorer motor skills and vice versa; children with poor motor skills are less physically active. This is attributed to feelings of being uncomfortable whilst being physically active (29). Children, who have poor motor skills and who are less physically active, also show a lower self-esteem, a lower self-confidence and a higher risk of encountering harassment (30).

In light of the above, promotion of physical activity in children is of high importance. Many attempts have been made to encourage children to be physically active. However, for example, in Amsterdam, these attempts have not led to a decrease of the obesity problem (31). Most projects had similar aims (encouraging physical activity, or body weight loss, or encouraging a healthy life style), but showed a short-term effect only, projects were not part of the daily routines of children, and organizations worked only within their area of expertise (31). In addition, particularly in after school sport participation projects, the already physically active children were gotten through to instead of the children in need of more physical activity (32).

THEORETICAL MODEL

Different theoretical models have been developed about health behaviour and changing health behaviour (33). The Theory of Reasoned Action (34) and the Theory of Planned Behaviour (35) imply that the most important determinant of behaviour is behavioural intention and perceived behavioural control. Direct determinants of individuals' behavioural intention are attitude towards performing the behaviour and the subjective norms associated with the behaviour. Perceived control accounts for situations where one may not have complete volitional control over a behaviour. Both theories assume a causal chain that links behavioural beliefs, normative beliefs, and control beliefs to behavioural intentions and behaviours via attitudes, subjective norms, and perceived control. Other factors, including demographic and

environmental characteristics, are assumed to operate through model constructs and do not independently contribute to explain the likelihood of performing a behaviour. See Figure 1 for an integrated model of the Theory of Reasoned Action and the Theory of Planned Behaviour (36).

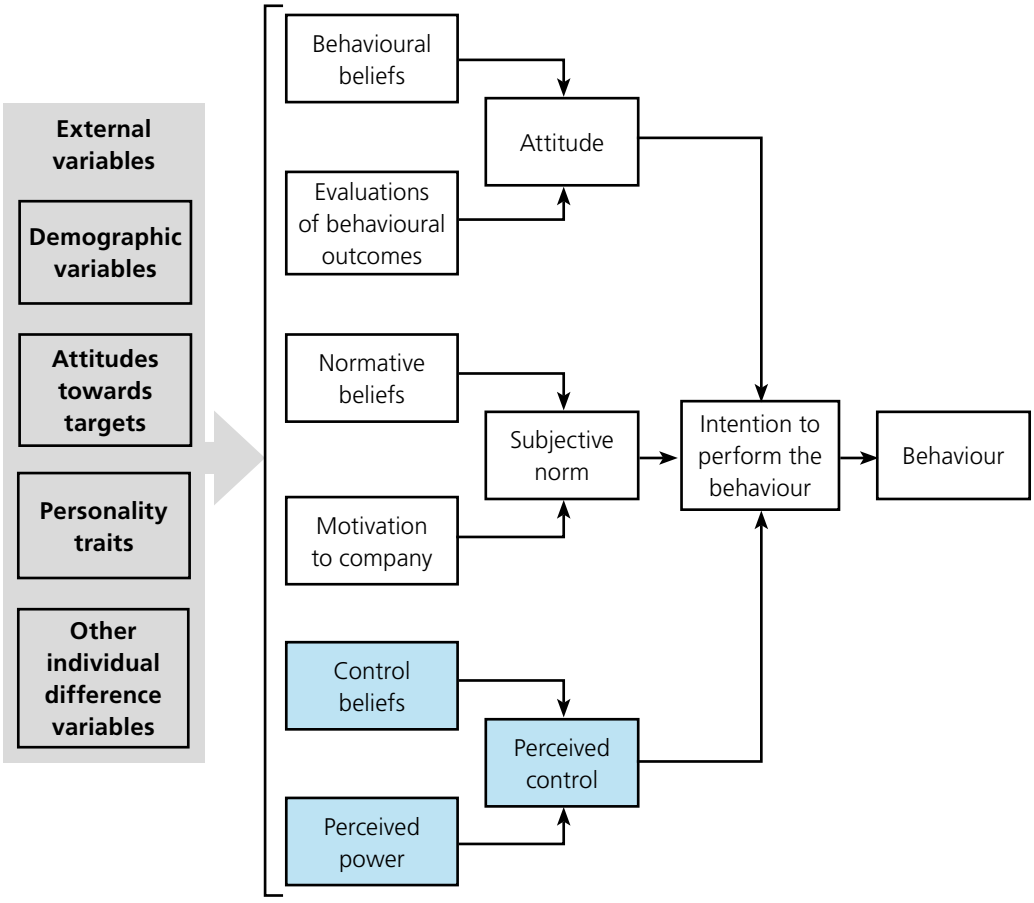

*Figure 1: Theory of Reasoned Action and Theory of Planned Behaviour.**
**Note: White boxes show the Theory of Reasoned Action; entire figure shows the Theory of Planned Behaviour. From (36).*

Children have less autonomy in their behavioural choices. The concept of habit has been shown important in dealing with physical activity (37, 38). The theoretical ecological model hypothesizes a direct influence of the environment on behaviour, unmediated by cognitive factors (39, 40). See Figure 2 for the ecological model.

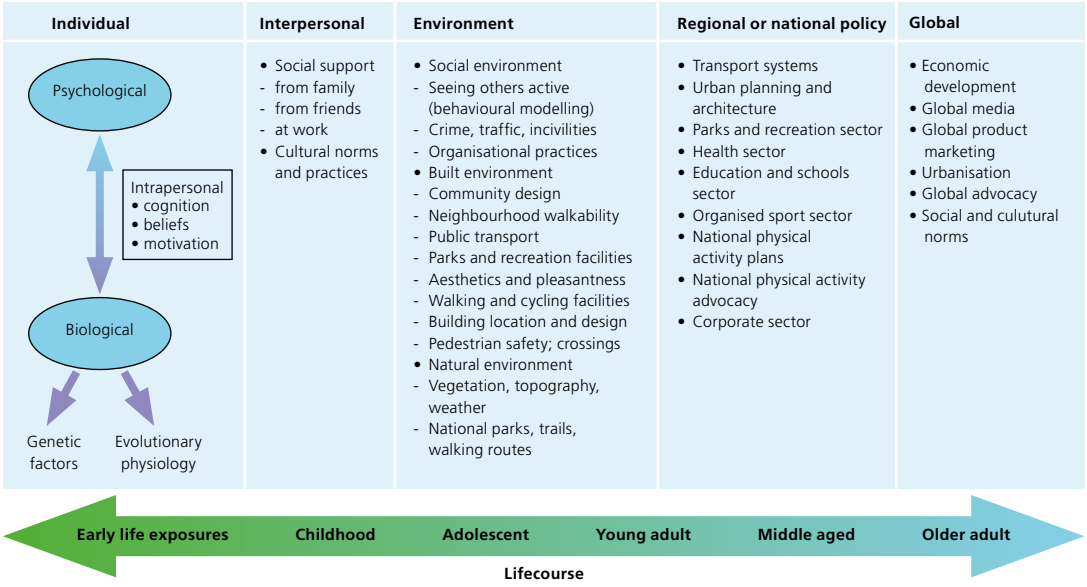

Figure 2: Ecological model (from 41)

PA PROMOTION VIA SCHOOL

Research has shown that environmental factors can have a significant impact on increasing habitual physical activity levels in children and adolescents (42). Since all children, regardless of their socioeconomic or cultural background go to school, school offers the opportunity to reach all children for the promotion of regular daily PA (43). At schools where PA habits are encouraged, an association with improved physical fitness was found (44).

A systematic review showed that effective environmental measures at school for encouraging PA levels in children are mainly PA-related policies (f.e. time allowed for free play, time spent outdoors, and number of field trips) (45). Recess represents an important context in which children have the opportunity to freely interact with their peers and to be physically active.

THE SCHOOL'S PLAYGROUND

Research has shown that at most playgrounds the play space per child is limited, due to the large number of children at the playground at the same time (46). In addition, social structures such as a hierarchy of power, based around age and gender (47), push the more timid children to the side of the playground. This results in low average physical activity levels at the playground (48).

Therefore, different playground programmes have been developed based on an environmental

change of the playground. A recent review on the effect of school recess interventions on physical activity showed that the levels of evidence were not sufficient to establish conclusive intervention effects, especially when strategies were combined (49). In addition, most playground interventions had a short-term follow-up, which may have captured novelty effects of the interventions.
However, the review showed promising strategies to increase physical activity during recess. Single intervention strategies have been found to be effective in several studies, for example, applying playground markings (50-52) and providing play equipment (53). Also for time-management (54) and increasing the amount of playground facilities (55) significant effects on PA level have been found. Besides such environmental changes, educational or social measures such as supervision and encouragement from adults (56) have also shown to be effective in increasing PA during recess.

PLAYGROUNDS

The PLAYgrounds programme is a multi-component programme, in which different effective components from earlier studies have been compiled. The PLAYgrounds programme consists of a combination of management of the playground environment – and thereby creating a more balanced use of the playground by all children – of providing equipment, encouragement by adults and a supporting Physical Education (PE) programme. The PE programme is supportive for teachers (how to encourage and support at the playground) and for children (agreement on game rules, increasing motor skills and providing a monthly stimulus with activity themes). Research shows that the effect of an environmental intervention is increased when the intervention is supported with information and lessons (38).

The follow-up of the PLAYgrounds programme was conducted during a whole year in order to measure the sustainability of the programme.

PA AND COGNITIVE PERFORMANCE

One of the components of the PLAYgrounds programme is the encouraging role of the classroom teacher. They often do not feel responsible for the amount of physical activity during recess, mainly because they feel that they deserve a break too. In addition, the primary responsibility of schools is to improve cognitive skills. As a result of this responsibility schools are under pressure to improve academic scores at the expense of the integral (healthy) development of the child. This often results in additional time for cognitive subjects and less time for PA for example during recess.
Nevertheless, a recent review has shown that children who are less physically active, and therefore often have a low physical fitness and/or poor motor skills, also show poorer cognitive skills (57). In addition, a rather strong association was found between PA and academic scores (58). Despite the expanding literature on the relationship between general PA levels and cognitive performance, evidence for an acute effect of PA on academic performance is limited, especially in the schoolsetting (57, 59).
A number of executive functions are essential for the academic performance of primary school children (60). One of these executive functions is selective attention, which is the ability to process specific target information while ignoring irrelevant information (61). Selective attention increases efficiency, improves sensory discrimination and is helpful for memory. Attention acts as a 'gate' into the working memory, regulating the flow of sensory information into conscious awareness (62). It has been shown that selective attention impacts language, literacy, and math skills. A few studies have been done in order to measure the effect of an acute PA break on selective attention.

Although some studies reported a significant effect, the results are thin, mainly due to differences and weaknesses in study design and different study samples (57, 59). In addition, the results from experiments in the school setting are inconclusive (57, 59). Therefore, the purpose of one of the studies in this thesis was to gain insight into acute effects of experimental PA breaks of different intensity on selective attention in 10-11 year old primary school children.

OUTLINE OF THE THESIS

The first part of this thesis describes the development of PLAYgrounds, a playground intervention, aimed at increasing levels of PA during recess. The PLAYgrounds intervention incorporates effective components described in the literature. The evaluation of this intervention has a 10 month follow-up in order to measure the effectiveness of the intervention through the entire school year.
The second part of the thesis describes the effect of an acute bout of PA on selective attention as a proxy of academic performance.

RESEARCH QUESTIONS

In short, this thesis addressed the following research questions:

(1) What is the effect of the PLAYgrounds programme on the level of PA during recess in primary school children aged 6-12?
(2) What is the effect of the PLAYgrounds programme on physical fitness in primary school children aged 9-12?
(3) In line with research question 1 and 2:
    a. Are there differences in the effect of the PLAYgrounds programme on PA levels for children of different ages?
    b. Are there differences in the effect of the PLAYgrounds programme in PA levels for boys and girls?
(4) What are the barriers and success factors for translation of the PLAYgrounds programme into practice, using the RE-AIM model?
(5) What are the effects of an acute physical activity bout on selective attention (a systematic review)?
(6) What are the acute effects of physical activity of different intensities on the selective attention in primary school children aged 10-11?

Chapter 1 of this thesis deals with the explanation of the impetus for this study. The development and the design of the PLAYgrounds intervention is described in chapter 2.
The third chapter of this thesis presents the effectiveness of the intervention on physical activity during recess, after which the fourth chapter focuses on the effectiveness of the intervention on physical fitness. The fifth chapter examines the translation of the PLAYgrounds programme into practice according to the RE-AIM framework.
Chapter six introduces the second part of the thesis; systematically reviewing the literature on the acute effects of physical activity on selective attention. The seventh chapter presents results from an experimental study on the acute effect of short physical activity breaks on selective attention. The thesis is concluded with a general discussion and a summary of findings in both the English and Dutch languages.

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CHAPTER 2

PLAYGROUNDS: EFFECT OF A PE PLAYGROUND PROGRAMME IN PRIMARY SCHOOLS ON PA LEVELS DURING RECESS IN 6- TO 12-YEAR-OLD CHILDREN. DESIGN OF A PROSPECTIVE CONTROLLED TRIAL

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ABSTRACT

BACKGROUND

The relative number of children meeting the minimal required dose of daily physical activity remains execrably low. It has been estimated that in 2015 one out of five children will be overweight. Therefore, low levels of physical activity during early childhood may compromise the current and future health and well-being of the population, and promoting physical activity in younger children is a major public health priority. This study is to gain insight into effects of a Physical Education based playground programme on the PA levels during recess in primary school children aged 6-12.

METHODS/DESIGN

The effectiveness of the intervention programme will be evaluated using a prospective controlled trial design in which schools will be matched, with a follow-up of one school year. The research population will consist of 6- to 12-year-old primary school children. The intervention programme will be aimed at improving physical activity levels and will consist of a multi-component alteration of the schools' playground. In addition, playground usage will be increased through altered time management of recess times, as well as a modification of the Physical Education content.

DISCUSSION

The effects of the intervention on physical activity levels during recess (primary outcome measure), overall daily physical activity and changes in physical fitness (secondary outcome measures) will be assessed. Results of this study could possibly lead to changes in the current playground system of primary schools and provide structured health promotion for future public health.

BACKGROUND

The health benefits of an active lifestyle are well established (1-5). Sedentary lifestyle habits are a major international and Dutch Public Health (PH) problem (1). A recent study in the Netherlands revealed that less than 10% of the children in primary schools (ages 4 through 11 years) achieve 30 minutes of physical activity (PA) per day (6), while the guidelines state a minimum of 60 minutes of PA per day for children in this age range (7). Although between the ages 12 and 17 this percentage triples to around 30%, the number of children meeting the minimal required dose of daily PA remains execrably low. In addition, children's PA has been identified as a modifiable risk factor for lifestyle related diseases such as coronary heart disease (7, 8) and osteoporosis (7, 9). Therefore, low levels of PA during early childhood will compromise the current and future health and well-being of the population (10), and promoting PA in younger children is a major PH priority (1, 6).

Schools have been recognized as key settings in promoting PA (6, 10-13). Next to the home, the school is the environment where children spend most of their time (6, 11-13). Within the school, physical education (PE) lessons and recess (i.e. regular playtime breaks) represent the two main contexts in which children have the opportunity to be physically active (6, 11-13). Next to such structured and frequent PA opportunities, schools can cater irregularly for sporting days and other extra-curricular activities (e.g. swimming). For the promotion of PA in the school setting, interventions targeted at recess have an important advantage over other interventions. While other physical activities provided by the school are on an irregular or non-daily basis, during recess all children have the opportunity to be physically active every single day. In addition, it has been suggested that younger children are more likely to participate in moderate to vigorous PA within unstructured play settings as opposed to more structured contexts (14). To stimulate PA in children, different playgrounds in Dutch neighbourhoods have been developed (e.g. Cruyff Court, Krajicek Playground, Nike Zoneparc). At these playgrounds children have an energy expenditure of about 206 kcal/hour and participate in moderate to vigorous PA 35% of the play time (15). Unpublished pilot research for this study on other, not specifically stimulating, playgrounds show that children participate in moderate to vigorous PA 10-30% of the playtime. One of the stimulating playgrounds, Nike Zoneparc, is placed on the school grounds to stimulate PA in children, but this playground costs about Euro 50,000.

Research in the United Kingdom in children aged 4-11 years, showed that the application of simple multicoloured markings on the school's playground significantly increased children's participation in moderate and vigorous physical activities on both the short-term (12) and long-term (13). In addition it was found that children who were less active at baseline, benefited more from this intervention than their more active peers. Such a simple and cheap intervention has great potential also in the Dutch setting. A recent Dutch study revealed that in primary school-aged children, PA levels are below recommended guidelines (6). This especially holds true for neighbourhoods in which the part of the population consisting of immigrants is relatively high (16). The lower PA levels are suggested to be due to the lower level of participation in organized sports and PA. The latter is a major issue for girls, while some may not participate in organized sports and PA due to their religious or cultural beliefs. The ability to give such groups of children the opportunity to be physically active on a daily basis during school recess has great potential PH gain. Next to descriptive information, this Dutch study (6) also described that children in primary schools prefer a re-structuring of school playgrounds in order to make better use of the playground. In

addition, the PE teacher has the ability to support physical activity further by linking the playground to the PE curriculum (15). In this study playground alterations in combination with a supporting PE programme will be evaluated.

OBJECTIVE

The objective of this prospective controlled trial is to gain insight into effects of a PE based playground programme on the amount and level of PA in primary school children aged 6-12. This overall aim can be subdivided into five research questions that will be addressed in this study:

(1) What is the effect of the playground programme on the amount and level of PA during recess in primary school children aged 6-12?
(2) What is the effect of the playground programme on the amount and level of daily PA in primary school children aged 9-12?
(3) What is the effect of the playground programme on physical fitness in primary school children aged 9-12?
(4) Are there differences in the effect of the playground programme on PA levels for children of different ages?
(5) Are there differences in the effect of the playground programme in PA levels for boys and girls?

METHODS/DESIGN

The CONSORT statement was followed to describe the design of this study (17). This statement provides a checklist intended to improve the quality of reporting randomized controlled trials.

HYPOTHESIS

It is hypothesized that recess PA levels will increase as a result of the intervention. In addition, an increase in the amount of daily PA is hypothesized. As a result of the positive effects mentioned above, overall fitness is expected to improve. It is hypothesized that boys have higher PA levels than girls (15) and that PA levels of younger children will be increased more as a result of the intervention than PA levels of older children (15).

STUDY OUTLINE

The PLAYground study is a prospective controlled trial with a follow-up of one school year (corresponding to approximately 9 months) in a group of about 1,200 children from 8 primary schools. Intervention and control schools will be matched according to number of pupils, geographical location, playground size and usage of the playground before the intervention. Baseline measurements for playground usage take place before the curricular year (June 2009), baseline measurements for fitness and overall PA take place at the start of curricular year (September 2009). Follow-up measurements for PA take place in January (mid-year) and in June 2010 (end of the curricular year). Follow-up measurements for fitness and overall PA will also take place in June.

The study is funded by the board of the schools, the Stichting Westelijke Tuinsteden (STWT) and by the Academy of Physical Education, Technical University of Applied Sciences of Amsterdam (ALO, Hogeschool van Amsterdam). The study design, procedures and informed consent procedure are approved by the Medical Ethics Committee (2010/222; NTR2386) of the VU University Medical Centre, the Netherlands.

The research population will consist of 6- to 12-year-old primary school children. All children at the participating schools will participate in this study following passive informed consent as has been used in comparable studies (18, 19). Schools will inform all parents on the study goals and procedures. If a parent does not want their child(ren) to participate in the study, this can be indicated, after which the child will be excluded from the study population.

SAMPLE SIZE

For the power analysis, data from a previous descriptive study on PA during school recess in primary schools was used (20). This study showed that at most 40% of the children participate in at least moderate PA during school recess. Results from a pilot study revealed that a doubling of the percentage of children participating in at least moderate PA is feasible. In order to establish such an effect with a power of 90% and an alpha of 0.05, a total sample of 64 children split across two groups is needed. While schools will serve as intervention units ideally a cluster effect should be taken into account when establishing group size. Assuming an intra-cluster correlation coefficient of 10%, a study sample consisting of 8 schools (4 intervention schools and 4 control schools) is required. Based upon a careful low-end estimate of approximately 150 participating children attending at these primary schools, this will result in a sample of about 1,200 children.

RECRUITMENT

The eligible research population will consist of 6-12-year-old children (n = 1,200). The board of schools (STWT) and the management of the schools already gave their approval for this study. All of the participating primary schools in the urban area of Amsterdam are located in neighbourhoods with a relatively large part of the population consisting of foreign descent immigrants. The schools will be recruited through the STWT. All schools that are part of the STWT will be informed about the study. Interested schools may receive additional information, after which they are free to choose to participate. Intervention and control schools will be matched according to number of pupils, geographical location, playground size and usage of playground before intervention. Schools that participate as control school first, will be offered the same intervention after this study in the following curricular year, when proven effective.

For the determination of playground usage the playgrounds will be observed according to a validated standardized protocol (SOPLAY) (21), which consists of observations on the quantity of use of the playground in general, quantity of use of the playground by different groups of interest (e.g. age and gender), type of PA activities, intensity of PA, and aspects related to the physical environment (e.g. weather conditions, accessibility and teacher presence). With the SOPLAY protocol the playground will be scanned for child density and playground use every five minutes. One scan, including notation, takes one minute. The total observation takes one hour, which consists of 12 scans. To generate a reliable result for every playground, 5 observations per playground will be done in different weather conditions.

INTERVENTION

The intervention consists of a multi-component alteration of the schools' playground. The playground will be actually modified. In addition, playground usage will be increased through an altered time management of recess times, as well as a modification of the content of PE lessons. This intervention has been evaluated in a pilot study in one primary school from the same geographical area as the study setting.

Playgrounds of the intervention schools will be painted during the summer holidays according to the school's preference. An analysis of the existing playground will provide information for the new designs that will be applied to the playground. Examples of designs are a soccer field, a basketball set-shot area, a circle for circular activities, a dance area, a throw and catch area, a rope skipping area and a bounce area. By using a set of predefined markings a playground is recreated that is appealing to children of all age groups represented in this study. The basic idea behind all modifications is to give structure to the playground. This will ensure that the available space is divided between

children, such that compatible activities are clustered in the available space. In addition this benefits the choice for different games, as the setting of the games can be situated on the most ideal playground spot.

Some designs will be named as 'hotspots'. A hotspot is a place where the majority of children would like to play (e.g. a soccer field). Usage of hotspots will be spread over the different classes, so all children will have the opportunity to play at a hotspot once a week. Also the recess available time will be divided between the different classes. This will create more relative playground space and allows for more intensive play opportunity per child. Once a week teachers will be playing together with the children. Once a month parents will be invited to join the children at the playground.

A specific PE programme will further support the intervention. Themes of activities will be scheduled and the regular lessons of PE will present ideas on how to use the playground, fitting the theme of the month (for example rope skipping in April). The weekly frequency of regular PE is two times, with a duration of forty-five minutes per PE lesson. To further support the playground activities each class will have a box with playground attributes (for example ropes and balls) used in the physical activities.

OUTCOME MEASURES

The primary outcome measure of this study is PA levels of children during recess. Secondary outcome measures are overall daily PA and physical fitness.
Process outcome measures are: (1) factors that determine the success or failure of implementation of playground markings in primary schools; (2) enabling factors for a nation-wide implementation of playground markings in primary schools; and (3) possible explanations of the outcomes of the effect-evaluation.
These process measures will be assessed by questionnaires, in personal interviews (with children, teachers, and parents) and observations.

MEASUREMENTS AND FOLLOW-UP

In order to register PA intensity during recess, each school will be visited every fortnight. Measurements will take place during this visit and will consist of both objective as well as observational measurements.

ACCELEROMETERS

PA will be measured using accelerometers (ActiGraph ActiTrainer), which are a reliable and valid objective PA measurement tool for children and adolescents (22). During the researchers' fortnight visit of the schools, a total of 40 children of all ages (8 per grade) will be randomly chosen to wear an accelerometer during the school day. This is an arbitrarily chosen number, based upon the organizational ability to perform these measurements on a single day by the available research staff.

The ActiTrainer will be set at an epoch of one second to measure every change in intensity and the display will be turned off, so children will not be distracted by the ActiTrainer. The ActiTrainer will be called a 'growing meter' or an 'honesty meter', so children will not be stimulated to be more active just because of wearing the ActiTrainer.

Through these measurements it is possible to objectively register intensity and duration of PA during recess. Existing analytical CSA programmes (e.g. MAHUffe) are not usable to analyse the thus obtained data, as recess time only lasts 15 minutes. These current commercial programmes are set to analyse PA during a prolonged period of time, e.g. 5 consecutive days. For this reason a dedicated MATLAB programme to analyse the number of

counts during the short recess time was written. This MATLAB programme analyses the counts per minute for every child, and combines the resulting data with date of measurement, total time of measurement and grade, age and gender of the child.

QUESTIONNAIRES

A baseline questionnaire will be completed by the 9- to 12-year-old children before they will perform the physical fitness test. This questionnaire gathers information about demographics (grade, age, gender), current PA levels (sports and leisure time). A follow-up questionnaire after nine months measures any changes in the baseline PA behaviour.

PHYSICAL FITNESS

Physical characteristics, i.e. body height, body weight as well as physical fitness, will be measured through a combination of items from the EUROFIT test (23) and the MOPER test (24). The selected tests for this study are: one hand plate tapping, sit-and-reach, 10x5 Shuttle Run (MOPER and EUROFIT), standing broad jump, hand grip test, 20 m endurance Shuttle Run, anthropometry (body height, body weight) (EUROFIT) and bent arm hang. The bent arm hang is performed in the MOPER test and in the EUROFIT test with an elevated horizontal bar, but will be performed in this study at a rope instead of an elevated horizontal bar. Children step from a chair to bent arm hang in the rope and the time in bent arm hang will be recorded until the arms are not bent anymore. These tests give an overall image of the fitness of children (coordination, flexibility, endurance, strength and speed). The choice for these tests is based upon the organizational ability to perform these measurements within two PE lessons and to get a reliable result with different test leaders. A 20 m endurance Shuttle Run (EUROFIT) is performed instead of a 6 minute run (MOPER), because a warming-up is integrated in the Shuttle Run test. The flamingo balance test, the sit-ups in 30 seconds test (EUROFIT) and the leg lifting test (MOPER) have been left out because of the difficulty to get an objective result with different test leaders; the PWC170 (EUROFIT) has been left out, because a bike ergo meter test is not practical within two PE lessons; the vertical jump and the one-arm pull (MOPER) have been left out, because these tests measure the same construct as the standing broad jump and the hand grip test.

The EUROFIT test and MOPER test have been shown reliable and valid in Dutch children (25) and have reference values for 9-11 (MOPER) and 12-16 year (EUROFIT) old children. Therefore in this study only 9- 11-year-old children will perform the Physical fitness test. The follow-up measurement after nine months, measures any changes in the baseline physical fitness.

OBSERVATIONS

During the fortnight's school visit, two researchers will observe the school's playground during recess. Observations will take place according to a validated standardized protocol (SOPLAY) (21), which consists of observations on the quantity of use of the playground in general, quantity of use of the playground by different groups of interest (e.g. age and gender), type of PA activities, intensity of PA, and aspects related to the physical environment (e.g. weather conditions, accessibility and teacher presence).

PROCESS EVALUATION

The PLAYground intervention will be evaluated with the use of the RE-AIM framework. The RE-AIM acronym represents Reach, Efficacy/Effectiveness, Adoption, Implementation and Maintenance (26). All children and teachers from the intervention group will complete an extra questionnaire and be interviewed on the subjective response of the intervention programme and suggested improvements at follow up (January 2010 and July 2010).

STATISTICAL ANALYSES

The effectiveness of the PLAYground intervention will be analysed by means of a multilevel regression analysis with the outcome measures at follow-up (9 months) as the dependent variables and adjusting for the baseline levels of the outcome measure. Both crude and adjusted analyses will be performed. Regression analyses will be performed using SPSS 18.0 (SPSS Inc. Chicago, Illinois, USA). For all analyses a two-tailed significance level of <0.05 will be considered statistically significant.

DISCUSSION

The effects of the intervention on PA levels during recess (primary outcome measure) and overall daily PA and physical fitness (secondary outcome measures) will be assessed. Results of this study could possibly lead to changes in the current playground system of primary schools and may provide structured health promotion to enhance future public health.

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CHAPTER 3
EFFECTIVENESS OF THE PLAYGROUNDS PROGRAMME ON PA LEVELS DURING RECESS IN 6-YEAR-OLD TO 12-YEAR-OLD CHILDREN

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ABSTRACT

AIMS

Worldwide levels of daily physical activity (PA) in children are low. This has negative health consequences. Schools have been recognised as key settings to promote PA. This study evaluates the effectiveness of the playground programme PLAYgrounds on increasing PA.

METHODS

PLAYgrounds was evaluated by a controlled trial, with a follow-up during one school year (10 months). Accelerometer data were collected on 1500 children in total, divided over 19 sampling moments (every 2 weeks). SOPLAY data were collected at nine sampling moments (once a month). Four intervention and four control schools were matched for playground size, number of pupils and PA levels at baseline. The intervention consisted of restructuring the playground by playground markings and by encouragement of the active use of the playground, through the provision of play equipment and educational measures such as adult encouragement and supporting physical education classes. Multilevel regression analyses were performed to analyse the effects of the intervention.

RESULTS

PA levels in the intervention group (moderate PA) were significantly different ($p<0.001$) from the control group (light PA). During the intervention on an average 77.3% of the children engaged in moderate-to-vigorous physical activity in the intervention group and 38.7% in the control group. The effect of the intervention was significantly stronger for girls than for boys ($p<0.001$).

CONCLUSION

The PLAYgrounds programme was effective in increasing PA levels in children during recess over the course of one school year. Thus, the programme could be used to provide structured PA promotion.

INTRODUCTION

Low physical activity (PA) in children is a cause for concern. On average, globally only 34% of the children between the ages of 4 and 12 years meet the guideline (1) of a minimum of 60 minutes of at least moderate intensity PA per day on each day of the week (2). This is troublesome as physical inactivity is related to a multitude of short-term and long-term negative health consequences in children, such as high-blood cholesterol, high blood pressure, markers of the metabolic syndrome as a cardiometabolic risk, overweight and obesity, low bone density and depression (3). Therefore, promoting daily PA in children is a major public health priority.

Schools have been recognised as key settings for promoting PA, with children spending a large part of their regular days in school (4). Within the school, physical education (PE) lessons and recess represent the two main contexts in which children have the opportunity to be physically active. Pate et al., (5) showed that PA in an organized setting, but where children choose their activities freely to interact with their peers, is the best way to accumulate PA.

During recess children are free to choose their activities. However, social structures such as hierarchy of power based around age provide less play space for the more timid children. Pellegrini and Smith (6) for example, showed that when soccer (which is usually played by the strongest boys) became less dominant, more opportunities were created to be physically active for the other children at the playground. Zask et al., (7) showed that less physically talented children were more likely to participate in PA in schools with a lower number of pupils at the playground (e.g. more play space per child).

Besides restricting activities that dominate the playground to specified areas or allowing fewer children at the same time at the playground, different other approaches have been shown to be effective in increasing PA. These include playground markings (8–10) time-management (11), obstacle courses or fitness breaks (12), equipment provision (13) and increasing the amount of playground facilities (14). Besides such environmental changes, educational or social measures such as supervision and encouragement from adults (15) are also shown to be effective in increasing PA during recess.

However, most studies had a short-term follow-up and evaluated only a single intervention measure. Therefore, we developed the multicomponent PLAYgrounds programme in which different effective components from earlier studies have been compiled. The PLAYgrounds programme consists of a combination of management of the playground environment, and thereby creating a more balanced use of the playground by all children of providing play equipment and of encouragement from adults. The aim of this study was to develop an effective and sustainable programme to encourage PA levels during recess in 6-year-old to 12-year-old children. Therefore, the follow-up was conducted during a whole school year. This paper reports on the effectiveness of the PLAYgrounds programme to encourage PA levels during recess in 6-year-old to 12-year-old children.

METHODS

PARTICIPANTS

In 2009–2010, eight public primary schools (four intervention, four control) consisting of 2310 children of 6-year-old to 12-year-old participated in this prospective controlled trial, with a follow-up of one school year (September-June, 10 months). Intervention and control schools were matched according to the number of pupils (250-450), playground size (600-1200 m2) and baseline playground use, that is, the average

level of energy expenditure at the playground as determined through the SOPLAY observational protocol (16). After matching, schools were randomly allocated to the intervention or control condition.

All schools were located in the urban area of Amsterdam in neighbourhoods with a relatively large part of the population consisting of children of immigrant origin with a low socioeconomic status. Similar to another school-based study (17) parents of the participating children received a passive informed consent form that explained the nature and procedures of the study allowing them to withdraw. The Medical Ethics Committee of the VU University Medical Centre approved the study design, protocols and informed consent procedure (NTR2386).

INTERVENTION

A full description of the intervention has been published previously (18). Briefly, the intervention consisted of restructuring the playground by multi-coloured lines by which specific areas for different activities were created (i.e. a soccer field, a basketball set-shot area, a circle for circular activities, a dance area, a throw and catch area, a skipping area and a bounce area). Through 'hotspots' management (i.e. a place where the majority of children would like to play) all children, including the more timid, were to be able to play at these areas.

In addition, altered recess time management, by using a recess schedule which allowed a maximum of two classes at the playground at the same time, reduced the number of children on the playground at any given time, thus creating more play space per child.

In the Netherlands, recess is a daily 15 minute playtime break in the morning and is embedded in the regular school day. Most children go home for lunch. The intervention focused only on the morning recess and was aimed at increasing the intensity of PA. Increasing the intensity of recess PA could result in recess making a substantial contribution to children's daily PA.

Active usage of the playground was encouraged through the provision of play equipment and monthly themes, and through supervision and encouragement by teachers. The amount of equipment was controlled for by using a standard set of equipment for different age groups, consisting of balls, juggling equipment, ropes, throw and catch equipment and equipment for tag games, crossing games and running games). Each class received a box with play equipment. The regular PE lessons presented ideas on game rules, on how to use the playground, play equipment and the themes that provided a new stimulus every month. All PE teachers received instruction materials and had six meetings with the researcher for training and support. The teachers encouraged the children of their own class during recess, which was a new part of their duty besides the regular supervision and in addition, they were scheduled to participate on the playground together with the children once a week.

DEMOGRAPHIC INFORMATION

The school register provided demographic information (age, gender and ethnicity). Children were classified as being of western or non-western descent following the Dutch Central Bureau for Statistics definition (CBS 2000). A child was classified as non-Western if the child itself or at least one parent was born in Africa, Latin America, Asia (except for Japan and Indonesia) or Turkey.

MEASUREMENTS

Outcome measures of this study were the average level of PA in children during recess expressed in counts/min and in energy expenditure (kcal/kg/min). In addition, the proportion of children who

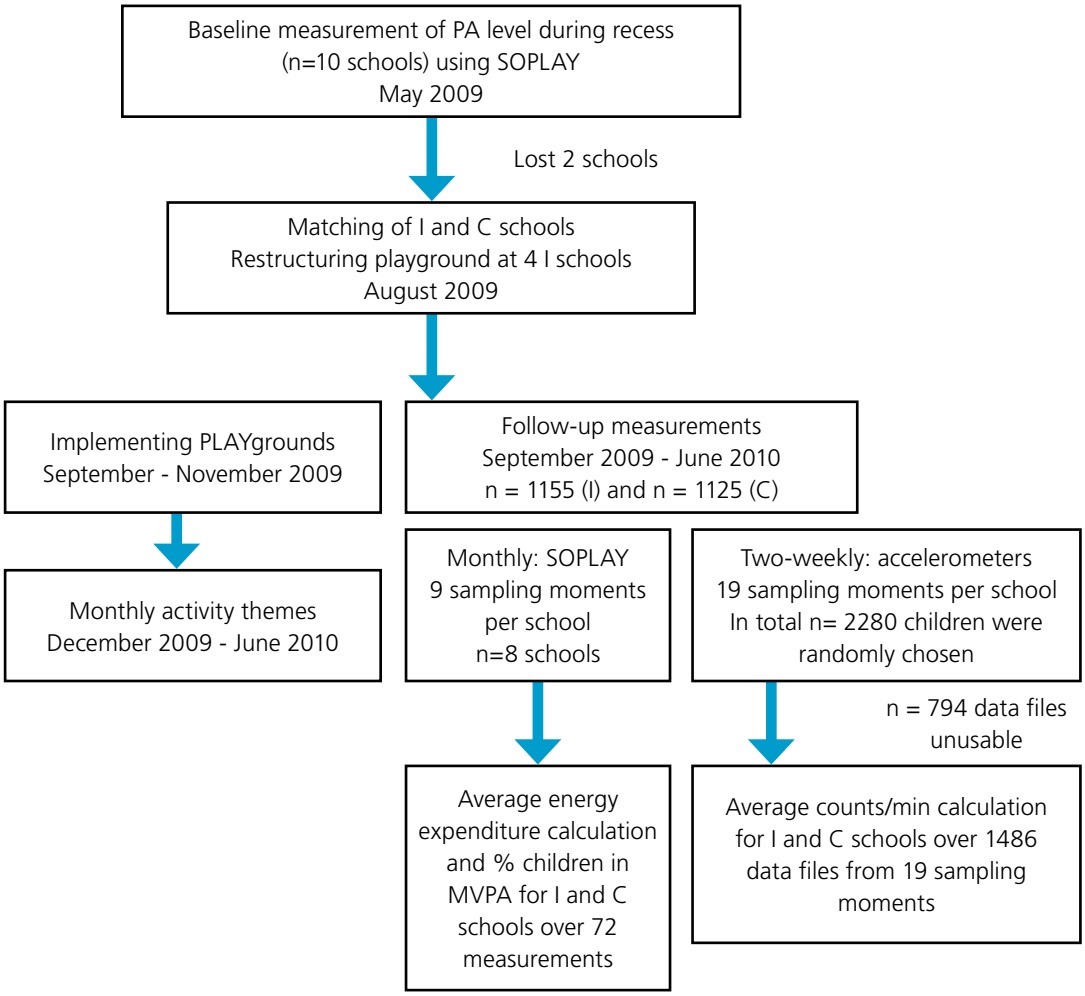

Figure 1: Flowchart of the measurements and intervention. I = intervention schools; C = control schools; n = number; % = percentage of.

were engaged in moderate-to-vigorous physical activity (MVPA) was assessed. Measurements consisted of both objective (accelerometry) and observational (SOPLAY) measures.

Figure 1 shows a flow chart of the measurements and intervention.

ACCELEROMETRY

Each school was visited every 2 weeks on the same day of the week. Accelerometry measurements were conducted during recess, using triaxial accelerometers (ActiGraph, ActiTrainer). In children the validity of the ActiGraph to measure daily levels of PA is moderate-to-good (19, 20).

For our purpose we measured the total number of accelerometer counts during a 15 minute bout of PA in a controlled setting.

At the start of the school year a random sequence was made in which the children were selected to wear the accelerometer following the school register. Per visit a total of 15 children of all ages (2-3 per grade) wore an accelerometer during recess. The accelerometer was securely attached to the children's hip by an elastic waist belt. The epoch length was one second and the display was turned off in order to minimise distraction.
In total, 2280 children were selected to wear the accelerometer during a total of 19 sampling moments at each school. Due to several reasons – for example children being absent on the day of measurement, children who switched schools or because of technical failure – 1486 data files were usable for analyses.
Counts per minute for the middle 12 minutes of the 15 minutes recess were derived and analysed, because after subtracting the time required to walk to and from the playground, an average net time of 12 minutes remained.

The following cut-off points were chosen, because they were the most appropriate for our population: light PA below 2000 counts/min, moderate PA between 2000 and 2999 counts/min (moderate) and vigorous PA over 3000 counts/min (21). These cut-off points correspond with approximately <3, 3–6 and >6 metabolic equivalent of task (METs) (21).

OBSERVATIONS

Once a month, on the same day as the accelerometry measurement, two people observed the school's playground during recess with the validated SOPLAY protocol (16). SOPLAY is a standardized protocol consisting of observations on the quantity of use of the playground in general, type of PA, intensity of PA and aspects related to the physical environment (e.g. weather conditions, provision of playground equipment, accessibility and teacher presence).

Eight students from the Academy for Physical Education were trained to observe together with the researcher (per school one student and the researcher). Training consisted of practising at different playgrounds to get familiar with the SOPLAY protocol and the registration of the different variables (like intensity and type of PA). An inter-observer agreement of 88-96% between the different students and the researcher was obtained after 16 hours of training.

Before each observation, the physical environment aspects were registered. The playground was observed as a whole, every 5 minutes during a recess, from left to right. During the intervention period, a total of nine sampling moments per school were done.

Following the SOPLAY protocol, the number of children that engaged in sedentary, walking and very active behaviour was counted to get a summary score and was then transformed into estimates of energy expenditure (kcal/kg/min), by multiplying these with a constant (sedentary; 0.051 kcal/kg/min walking; 0.096 kcal/kg/min and very active; 0.144 kcal/kg/min). These categories are in agreement with the MET values for sedentary (±3 METs), moderate (±6 METs) and vigorous (±9 METs) PA. The transformation of observational data into energy expenditure provided an average level of energy expenditure during recess. The data were also analysed regarding the proportion of children that were engaged in MVPA by counting the children who were observed to be moderate to vigorous physically active and divided by the total number of children.

STATISTICAL ANALYSES

Baseline measurements were compared using independent t-tests (energy expenditure and age) and Pearson Chi-square (ethnicity and gender) in SPSS V.18.0 (IBM). The effectiveness of the PLAYgrounds intervention was analysed by means of a linear multilevel regression analysis to account for the clustered nature of the data. In the multilevel analysis, a two level structure was considered; that is, children were clustered within schools (accelerometry) and sampling moments were clustered within schools (SOPLAY). Beside a crude analysis, an analysis was performed adjusted for season (categorical, four seasons), gender (dichotomous) and age (categorical, three age groups: 6-8, 9-10 and 11-12 years old). In additional analyses on the accelerometer data it was investigated whether season, gender and age were effect modifiers. All multilevel analyses were performed using MLwiN (V.2.21) and a two-tailed significance level of $p<0.05$ was considered statistically significant for all analyses.

RESULTS

PARTICIPANTS

Descriptive characteristics of the children who participated in this study as well as average PA at the playground at baseline are shown in table 1. At baseline, there were no significant differences between the intervention and the control group. The average level of energy expenditure during recess was 0.075 kcal/kg/min (SD 0.01) for the intervention group and 0.082 kcal/kg/min (SD 0.02) for the control group, which corresponds with, respectively, 4.5 and 5 METs (i.e. light PA). In the intervention group 39.6% of the children were engaged in MVPA and 41.2% in the control group.

Table 1 Baseline characteristics

	Intervention	Control
Number of participants (%)	721 (48.5%)	765
Age, years, mean (SD)	8.6 (1.5)	8.7 (1.5)
Gender, number (%) - Boys - Girls	 404 (56.0%) 317	 424 (55.4%) 341
Ethnicity, number (%) - Western - Non-Western	 58 (8.1%) 663	 66 (8.6%) 669
Energy expenditure, kcal/kg/min, mean (SD)	0.075 (0.01)	0.082 (0.02)
Proportion of children in MVPA, %	39.6	41.2

SD = standard deviation

PHYSICAL ACTIVITY

Table 2 shows the average PA levels during the intervention. The average counts/min over the course of one school year in the intervention group was 3924 (SD 466) and in the control group 2178 (SD 738) measured by accelerometers. This corresponds, respectively, with vigorous PA (>6 METs) and moderate PA (3-6 METs). The SOPLAY observations showed that the average amount of energy expenditure at the playground was 0.105 kcal/kg/min (SD 0.01) for the intervention group and 0.074 kcal/kg/min (SD 0.01) for the control group. This corresponds respectively with moderate PA (6 METs) and light PA (4 METs). During the intervention, an average of 77.3% of the children in the intervention group was engaged in MVPA, against 38.7% of the children in the control group.

Table 2 Average PA levels (over a school year) during the intervention, measured by accelerometry (counts/min) and by SOPLAY (energy expenditure and proportion of children in MVPA)

	Intervention	Control
Counts/min, mean (SD)	3924 (466)	2178 (738)
Energy expenditure, kcal/kg/min, mean (SD)	0.105 (0.01)	0.074 (0.01)
Proportion of children in MVPA, %	77.3	38.7

MVPA = moderate-to-vigorous physical activity;
PA = physical activity

Table 3 Effectiveness of the intervention measured by accelerometry and by SOPLAY

Accelerometry	B (95% CI)	p-value
Crude model	1747 (1666 – 1827)	<0.001
Adjusted model[a]	1706 (1642 – 1769)	<0.001
SOPLAY		
Crude model	*0.031 (0.027 – 0.035)*	*<0.001*

[a] *Adjusted for season, gender and age*
B: regression coefficient

Table 3 shows the effectiveness of the intervention. In both the crude and adjusted model the intervention effect was significant (p<0.001). The accelerometer data showed that the intervention effect was stronger for girls (p<0.001, boys as reference) and different for the age groups, with the strongest effect for the oldest age group (10-12 years old (p<0.01, youngest age group as reference). An additional analysis with a three-way interaction between age, gender and intervention showed that the effect was strongest for 10-year-old to 12-year-old girls. The intervention effect also varied through the season, with the strongest effect during summer/autumn (the first season). Figure 2 depicts the intervention effect through the different seasons and the effect separately for boys and girls.

DISCUSSION

Multiple studies have been done to evaluate the effectiveness of playground alterations, playground programmes or playground management changes. Most of these studies have a small sample and/or a short-term follow-up. Therefore, our study evaluated the multi-component PLAYgrounds programme with a follow-up of one school year.
The PLAYgrounds programme was effective in increasing PA intensity level during recess, with a significant difference between the intervention group and the control group (p<0.001). The intervention group was on average moderately physically active as opposed to the control group who was lightly physically active. In the intervention group 77.3% of the children engaged in MVPA as opposed to 38.7% of the children in the control group.

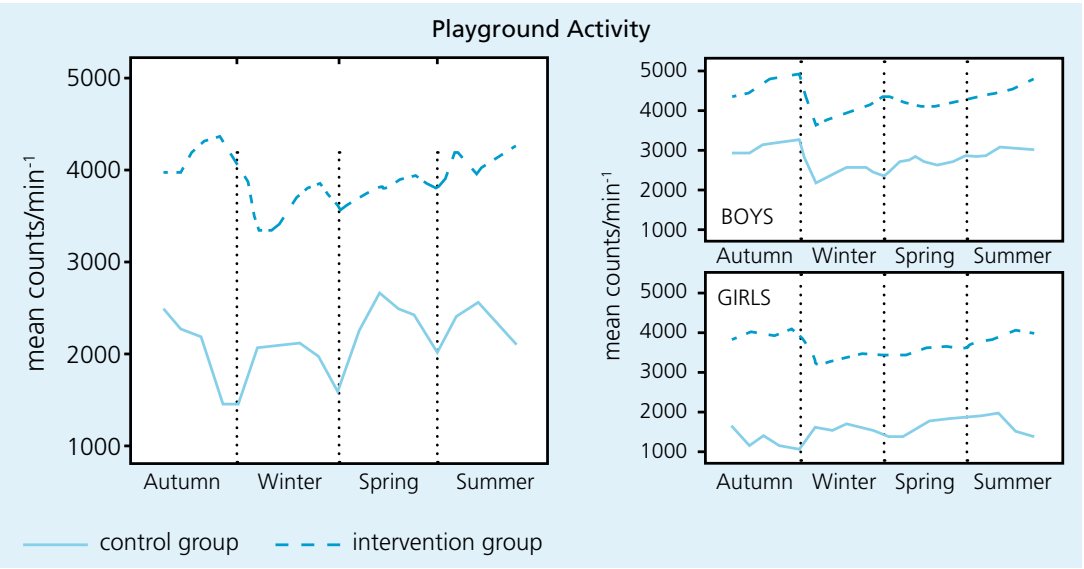

Figure 2: Seasonal fluctuations in physical activity intensity (counts/min) for intervention and control group (A), separately for boys and for girls (B).

Previous playground studies, using measures such as playground markings or equipment provision, were also effective in increasing PA during recess. A review on playground interventions (22) concluded that a number of factors affect children's PA levels during recess, such as playground space or prompts received. However, no studies evaluated the impact all of these factors together. In 2010, a prediction model was made to identify significant variables associated with the level of PA during recess (23). More play space and equipment provision were positive predictors for moderate PA. Our study combined more play space, which was created by restructuring the playground and educational measures, with equipment provision. Besides that, adult supervision and encouragement, as well as playground markings, were part of the PLAYgrounds programme, but these factors were not found to be positive predictors in the prediction model study from 2010. Conversely, these factors were found to have a significant effect in experimental studies (10, 15).

The intervention effect was stronger for girls than for boys, which might be explained by the nature of the intervention programme. The PLAYgrounds programme consisted of different components that appeal to girls in particular (e.g. a designated skipping and dance area). In addition, by creating a specific area for soccer, there was a more balanced partition of the playground among boys and girls. Due to the PLAYgrounds programme, PA levels in especially older girls increased from sedentary to moderate PA. This is quite promising for structured health promotion, since PA levels decrease across adolescence into adulthood (1, 24) and, in general boys, are more active than girls (24).

In most previous studies the largest effect of a playground intervention was at the start of the intervention and it decreased over time (22), which might imply a novelty effect. Our study showed that the PLAYgrounds programme provided a sustained stimulus for increasing recess PA levels during the whole school year, arguably because of monthly motivation with activity themes and PE support. However, a potential seasonal influence was also found. There is some evidence from earlier studies for such a seasonal effect, but most results are contradictory. The prediction model (23) mentioned previously showed a significant negative association between temperature and vigorous activity, but a review (25) showed that seasonal variations suggest higher PA levels during summer months. In our study, the association model was adjusted (among others variables) for season.

The validity and reliability of PA measurements are a general topic of discussion, due to variation in PA duration and PA levels which vary by assessment method (26). An observation method, such as SOPLAY, is subjective and the outcome depends on the researcher's estimation of the intensity of PA. Accelerometers provide an objective measure. On the other hand accelerometry is mostly validated for walking and running activities and the observation method is the most practical method for assessing different kind of activities (e.g. climbing and swinging). In this study both measurement methods were combined and both showed a significant difference between the intervention group and the control group as well as the same seasonal pattern during the school year. However, accelerometer data showed higher PA levels than SOPLAY data. Intensity thresholds for MVPA in youth measured by accelerometry varied widely between studies (27). In our study, cut-off points from Ekelund et al., (21) were chosen to specify the PA level from accelerometer data, because these were most appropriate to the group of participants in our study. With the
SOPLAY method an average energy expenditure of the playground is calculated, which is based on

predefined constants. Due to the variation in intensity thresholds for accelerometers and a different method of defining PA levels by SOPLAY, the results of this study expressed in intensity levels are not in agreement with each other. This makes the interpretation of the results in terms of PA levels ambiguous.

In our study the outcome measure was average PA level during recess. In most studies PA level is measured during a whole day or week and the outcomes are expressed in minutes spent in intensity levels or minutes spent in activities. The primary goal of our intervention was to encourage children to increase their PA levels during a short break. With regard to our intervention it was not important as to what kind of activities they were involved in, as long as they were physically active. In other countries recess lasts longer and children also have a lunch recess, arguably suggesting that the PLAYgrounds intervention which we evaluated could be more effective in school settings with multiple recess break (including lunch) during the school day.

The aim of the study was to increase PA levels and make recess contribute to the recommended daily PA. Following the Dutch Public Health (PH) guideline of minimal daily PA (28) intensity categories are based on <5, 5-8 and >8 METs, respectively, for light, moderate and vigorous PA for youth. For accelerometry, this corresponds with the cut-off points <4100 (light), 4100-8200 (moderate) and >8200 counts/min (vigorous) (29). This means that despite a significant intervention effect, the intensity level at the intervention schools still corresponds with light intensity PA, while the PH guideline recommends at least 1 hour of moderate intensity PA per day. On the other hand, the SOPLAY data showed that the intervention group engaged on average in moderate intensity PA during the intervention. This implies that the PLAYgrounds programme during recess could contribute 25% to the recommended daily PA levels, since recess is 15 min per day. Based on the results of this study, multiple moments of recess during the school day should be recommended to encourage children to be sufficiently physically active every day.

LIMITATIONS

There are several limitations when interpreting the results from this study. First, in the PLAYgrounds programme different factors were combined to stimulate PA during recess, but it is not clear as to which factor or factors contributed more than other factors. Besides that, the educational measures, such as the supporting PE programme as well as the adult supervision or encouragement were dependent on the motivation of the PE teacher and classroom teachers, although the researcher supported the teachers and evaluated the process. Second, a combination of measurement methods was used to evaluate the effect of the intervention. However, the interpretation of the data is still ambiguous when translating them into METs or into the proportional contribution to the PH guideline of required daily PA.

Data on the effectiveness of the intervention were only collected during recess and showed that children were more physically active. It could occur that children compensate this higher level of PA throughout the rest of the day, but since this was not measured, this remains unclear.

CONCLUSION

This study showed that the PLAYgrounds intervention programme, which combined structural playground changes with playground management in primary schools, increased average PA levels during recess along one school year and could be used to provide structured PA promotion.

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CHAPTER 4
EFFECTIVENESS OF THE PLAYGROUNDS PROGRAMME ON PHYSICAL FITNESS IN CHILDREN AGED 9-12

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ABSTRACT

PURPOSE:

Over time physical fitness (PF) levels in children have decreased in parallel with decreased physical activity (PA) levels. The PLAYgrounds programme has shown to be effective in increasing PA levels during recess. In this study the effect on PF levels was evaluated.

METHODS:

PLAYgrounds was evaluated using a prospective controlled trial. The intervention consisted of re-structuring the school playground with coloured lines and by encouragement of active use of the playground, through the provision of play equipment and supporting physical education lessons. PF was assessed by 7 selected tests from the Eurofit test battery and was assessed at baseline (September) and at follow-up (June). Multilevel regression analyses were performed to analyse the effect of the intervention.

RESULTS:

A significant difference at follow-up was found between the intervention group and the control group for plate tapping, 10x5m run and 20m shuttle-run in favour of the intervention group. The effect was stronger for the least fit children at baseline for 10x5m sprint and 20m shuttle-run. The effect of the intervention on 20m shuttle-run was stronger for girls than for boys.

CONCLUSION:

The PLAYgrounds programme was effective in increasing some indicators of neuromotor fitness (plate tapping and 10x5m run) and cardiorespiratory endurance in boys and girls.

INTRODUCTION

Without doubt, physical inactivity in children is a major public health concern. European studies have shown that 95.4% of the girls and 83.2% of the boys are unable to reach moderate-to-vigorous intensity PA recommendations of at least 60 minutes/day (1). Although many attempts have been made to encourage children to be physically active, total daily physical activity (PA) in children has decreased over the last 20 years (1). In parallel with decreased PA, physical fitness levels in children are decreasing (2-4). This is a cause for concern, as low cardiorespiratory fitness and reductions in cardiorespiratory fitness over time are significantly associated with the risk of being overweight (5). Currently, the prevalence of obesity is high; one in five children is overweight or obese (6). In addition, childhood physical inactivity tracks into adulthood (7) and inactive adults as well as adults with a low cardiorespiratory fitness have a higher risk of high blood pressure and cardiovascular disease (8). Therefore, it is necessary to encourage an increase in PA levels in children.

Co-operation with schools gives us the opportunity to reach all children for the promotion of PA (9). Multiple school playground interventions have shown a positive effect on PA (10-12). Also at schools where PA habits are encouraged, a positive association with physical fitness has been found (13). Yet, from a recent review it was concluded that effective interventions in the school setting on physical fitness need to be intensive and mandatory by nature (14). For example, the frequency and duration of physical education (PE) lessons may be insufficient to achieve the needed effects on physical fitness (14), since PE lessons are scheduled (in the Netherlands) only once or twice a week for about one hour. Recess may be a context during which children can be encouraged to be sufficiently active, yet only when certain measures (such as structuring the playground and time-management) are taken, in order to provide an appealing environment to be physically active (15) and to create sufficient play space per child.

For this purpose we developed the PLAYgrounds intervention, which is a school-based intervention aimed at improving PA levels during recess. This intervention has been shown to be effective on increasing PA levels (16). As a component of the intervention, parts of the regular PE lessons were dedicated to playground activities and in particular to practicing neuromotor skills. The children were required to perform different activities on the playground. One may hypothesize a positive effect of practising these skills through the PLAYgrounds programme on health-related fitness (i.e. cardiorespiratory endurance) and on neuromotor fitness from the increased PA levels. Therefore the aim of this paper is to describe the results of the PLAYgrounds programme on health-related fitness and neuromotor fitness in 9- 12-year-old children.

METHODS

In 2009-2010, a prospective controlled trial was done in four intervention and four control schools with a follow-up of one school year (September-June, 10 months). In total 2310 children of 6 to 12 years old participated in the PLAYgrounds study. Only the 9- to 12-year-old children participated in the PF measurements. Therefore a total of 740 children were available for this study. Table 1 shows the descriptives of the participants.

Table 1 Baseline characteristics

	Intervention	Control
Participants, n (%)	391 (52.8%)	349
Age, years, mean (SD)	10.7 (1.7)	10.5 (1.5)
Gender, n (%)		
Boys	201 (51.4%)	186 (53.3%)
Girls	190	163

n = number; SD = standard deviation

All schools were located in relatively low socio-economic status neighbourhoods in Amsterdam. Similar to other school-based studies (17), parents of the participating children received a passive informed consent form that explained the nature and procedures of the study, allowing them to withdraw if they wished to do so. The Medical Ethics Committee of the VU University Medical Centre approved the study design, protocols and informed consent procedure (NTR2386).

INTERVENTION

A full description of the PLAYgrounds intervention has been published previously (18). The intervention is described in short below. In the Netherlands, recess is a daily 15 to 30 minutes playtime break in the morning and is embedded in the school day. The intervention consisted of restructuring the playground as well as encouragement of active usage of the playground. The restructuring of the playground by which specific game spaces were created (i.e. a soccer field, a dance area etc.) was done by multi-coloured lines. A time schedule (i.e. allowing a maximum of two classes at the same time at the playground) and hotspot (i.e. a play space where the majority of children wanted to play) management were used to create more play space per child and a more balanced use of the playground. Active usage was stimulated by providing a box with play equipment and themes for activities presented in the regular PE lessons. The regular PE lessons included practising of neuromotor skills, which the children required for performing a variety of games on the playground, such as twin-wheel, juggling, running games, basketball skills and jumping exercises. In the PE lessons, themes for activities were presented that provided a new stimulus every month. For example, one of the themes was skipping and therefore different skipping games, skipping with different materials (ropes and elastics) and skipping techniques were practised.

MEASUREMENTS

The school register provided demographic information (age and gender). The outcome of this study was the level of physical fitness of the children. Physical fitness is defined by the Amrecia College of Sports Medicine (ACSM) as a combination of health-related fitness (flexibility, cardiorespiratory endurance, and muscular strength and muscular endurance) and neuromotor fitness (speed, agility, power and coordination) (19, 20). Measurements of physical fitness consisted of seven test items of the Eurofit test battery (21). Validity and reliability of the Eurofit fitness tests have shown to be acceptable (22). The follow-up measurement after 10 months measured changes in the baseline physical fitness. No information on body mass and body height was gathered, due to scheduled coinciding Health Service measurements at the participating schools. The Health Service measurements were not available for this study because of privacy laws.

EUROFIT TEST BATTERY ITEMS

Table 2 (next page) shows an overview of the selected test items, including a description of the physical fitness construct, the physical fitness domain, a description of measurement and the unit of score. The choice for these tests was based upon the organizational ability to perform these measurements within two PE lessons and to get a reliable result with different test leaders. The bent arm hang has to be performed with an elevated horizontal bar, but was performed in this study using a vertical rope. Children stepped from a chair to bent arm hang in the rope and the time in bent arm hang was recorded until the arms were not bent 90 degrees or more anymore. Therefore, the bent arm hang test was not a validated test item. For a detailed description of the measurement of the different test items, see the manual of the Eurofit test battery (21).

Table 2 Description of the fitness test items used in this study.

Test item	Physical fitness construction	Physical fitness domain	Measurement	Score
One hand plate tapping (PT)	Eye-hand coordination and arm speed	Neuromotor	Time needed to complete 25 cycles between two discs while alternatively tapping with the hand of preference as fast as possible	sec
10x5m run (10x5)	Running speed and agility	Neuromotor	Minimal time needed on a 10 times 5m run	sec
Bent arm hang (BAH)	Upper body strength and muscular endurance	Health-related	Maximal time that arms were bent 90 degrees or more while hanging in a vertical rope	sec
Sit-and-reach (SAR)	Trunk flexibility	Health-related	Maximal reach while sitting with extended knees	cm
Standing long jump (SLJ)	Explosive leg power	Health-related and neuromotor	Maximal standing horizontal jump distance	cm
Hand grip test (HG)	Static arm strength	Health-related	Maximal force pulled with preferred arm on a dynamometer while standing	kg
20m shuttle-run (SRT)	Cardiorespiratory endurance	Health-related	Run a maximum of stages while the time is shortened between stages	stages

Detailed test protocols were written for use by students from the Academy for PE and PE teachers located at the intervention and control schools. They were trained to administer the test items following a standardized protocol, including instructions to the children, vocal encouragement and the scoring. After a training period of 8 hours, an inter-rater reliability of at least 85% was scored. All tests were performed twice, and the best score was retained, except for the 20m shuttle-run (which was performed once at baseline and once at follow-up). All tests were performed within two PE lessons. In order to rule out any footwear influence, children performed all tests barefoot, except for the 20m shuttle-run.

STATISTICAL ANALYSES

Baseline measurements were compared between the intervention group and the control group using independent t-tests (age and baseline physical fitness) and Pearson Chi-square (gender) with SPSS 18.0 (IBM). Due to the clustered nature of the data, the effectiveness of the PLAYgrounds intervention on physical fitness was analysed by means of a linear multilevel regression analysis. In the multilevel analysis, a two level structure was considered; i.e. children were clustered within schools. Baseline measurements for the different physical fitness outcomes were included in all analyses as a covariate. Beside a crude analysis, analyses were performed adjusted for gender (dichotomous) and age (dicho-

tomous; two age groups 9-10 and 11-12 years old). In additional analyses it was investigated whether gender, age and level of physical fitness at baseline were effect modifiers. All multilevel analyses were performed using MLwiN (version 2.21) and a two-tailed significance level of $p<0.05$ was considered statistically significant for all analyses.

RESULTS

Table 3 shows the physical fitness scores of the children at baseline and follow-up. All physical fitness test data was distributed normally, except for the bent arm hang scores. Therefore the median of the bent arm hang scores is also provided. Due to the adjustment for baseline values of the outcome,

Table 3 Mean scores on the different test items in the intervention group and the control group at baseline and follow-up. For bent arm hang also median score is provided, since the data was not normally distributed.

	Boys				Girls			
	I		C		I		C	
Mean (SD)	**B**	**Fup**	**B**	**Fup**	**B**	**Fup**	**B**	**Fup**
Plate tapping (sec.)	14.06 (1.7) n=193	12.96 (1.8) n=184	14.37 (2.4) n=178	13.96 (2.1) n=179	13.37 (1.6) n=178	12.18 (1.8) n=177	14.38 (3.9) n=157	13.33 (2.2) n=157
10x5m run (sec.)	20.69 (1.8) n=193	19.15 (1.5) n=186	20.23 (2.1) n=180	20.00 (2.7) n=176	21.23 (1.9) n=178	19.6 (2.0) n=184	21.07 (2.0) n=156	20.6 (2.1) n=158
Bent arm hang (sec.) Median scores	13.37 (10.3) 11.0 n=193	13.36 (11.0) 11.0 n=189	15.19 (13.1) 12.0 n=179	15.36 (12.7) 12.0 n=178	11.32 (9.2) 9.0 n=178	12.77 (10.5) 9.0 n=180	11.24 (9.9) 7.0 n=157	11.78 (10.3) 8.0 n=157
Sit-and-reach (cm)	23.39 (6.8) n=193	23.58 (6.7) n=192	23.46 (6.8) n=177	23.97 (7.0) n=178	26.28 (7.2) n=178	25.80 (7.9) n=181	26.49 (7.3) n=157	26.39 (7.7) n=157
Standing long jump (cm)	127.12 (19.3) n=193	131.96 (18.7) n=183	132.44 (22.7) n=180	134.25 (23.1) n=177	125.48 (20.4) n=178	126.84 (22.4) n=180	123.41 (20.0) n=157	127.19 (19.9) n=157
Hand grip (kg)	17.99 (4.5) n=193	18.83 (4.7) n=186	17.77 (4.7) n=179	19.20 (4.8) n=178	17.82 (4.6) n=178	18.82 (4.3) n=179	17.94 (4.8) n=157	17.64 (3.9) n=157
20m shuttle-run (stages)	4.84 (1.8) n=192	5.54 (1.9) n=188	4.57 (1.8) n=185	4.94 (1.7) n=181	4.33 (1.5) n=178	5.55 (1.6) n=181	4.21 (1.8) n=140	4.12 (1.7) n=139

I = intervention group; C = control group; B = Baseline; Fup = Follow-up
n = number of children tested for that specific item; SD = standard deviation

the residuals of the multilevel analysis with bent arm hang as outcome were normally distributed and therefore, no transformation was performed. Table 4 presents the effectiveness of the PLAYgrounds programme on physical fitness levels. In both the crude and adjusted model, a significant difference was found between the intervention group and the control group on the test items plate tapping, 10x5m run and 20m shuttle-run in favour of the intervention group. Inverse interaction terms were found between the intervention and baseline scores for 10x5m run ($p<0.001$) and 20m shuttle-run ($p<0.001$), indicating that the intervention effect was stronger for the least fit children at baseline on these specific physical fitness tests. Gender was found to be an effect modifier ($p=0.004$) on the 20m shuttle-run. The effect of the intervention on the 20m shuttle-run was stronger for girls (B= 1.427; 95%CI= 0.76 – 2.10) than for boys (B= 0.446; 95%CI= -0.01 – 0.90). None of the other interactions were statistically significant.

Table 4 The effectiveness of the PLAYgrounds intervention on physical fitness levels for the different test items.

Test	Crude model: B [95% CI]	Adjusted model[a] B (95% CI)
Plate tapping	-0.813 [-1.37 – -0.26]*	-0.770 [-1.26 – -0.28]*
10x5m run	-1.119 [-1.91 – -0.32]*	-1.088 [-1.86 – -0.32]*
Bent arm hang	-0.145 [-1.34 – 1.05]	-0.221 [-0.98 – 1.42]
Sit-and-reach	-0.442 [-1.80 – 0.92]	-0.491 [-1.63 – 0.65]
Standing long jump	0.000 [-3.50 – 3.50]	-0.505 [-3.64 – 2.63]
Hand grip	0.171 [-1.08 – 1.42]	0.145 [-1.09 – 1.38]
20m shuttle-run	0.905 [0.49 – 1.32]*	0.910 [0.49 – 1.33]*

B = regression coefficient; CI = Confidence Interval
[a] adjusted for gender and age
**p-value < 0.05*

DISCUSSION

The aim of this study was to evaluate the intervention effect of a recess playground intervention on physical fitness levels of children. The intervention has already shown to be effective in increasing PA levels during recess (16). Other playground studies showed a significant effect on PA, but did neither measured effects on physical fitness (10), nor found a significant difference between intervention and control group for physical fitness levels (23). In our study we found a significant difference in favour of the intervention group for plate tapping, 10x5m run and the 20m shuttle-run, where the latter effect was stronger for girls.

Scores on the different test items are within the range of test items found in other studies (2, 24, 25) except for the hand grip test and the standing long jump. Our study population scored better on the hand grip test and worse on the standing long jump. Arguably, the results on the hand grip and standing long jump could be comparable to scores in other studies, when these results would be expressed in absolute scores. Differences in scores would then be explained by differences in body weight and body height, since our population consisted of a high proportion of children with overweight. Bent arm hang performance was not comparable to other study results, since in our study the test was performed on using a vertical rope instead of on a horizontal bar.

There is no agreement on the methods of assessment of physical fitness. In this study we chose to measure different constructs of physical fitness as defined by the ACSM (20). Our results show that neuromotor fitness (eye-hand coordination, arm speed, running speed and agility) had improved more than health-related fitness (flexibility, cardiorespiratory endurance, and muscular strength and muscular endurance), from which only cardiorespiratory fitness had improved. Cardiorespiratory en-

durance performance in young children has been shown to be associated with VO2max, which is accepted as a good reference standard of cardiorespiratory fitness (22, 26). Improving cardiorespiratory fitness can be achieved by being physically active with a minimum of 20 minutes, 3 times a week at moderate intensity (20).
Recess in the Netherlands lasts 15-30 minutes, and due to the PLAYgrounds programme children in the intervention group had moderate intensity PA levels (16), which might have been enough to improve cardiorespiratory fitness. The better improvement in cardiorespiratory fitness in girls could be explained by the fact that the greatest aerobic capacity benefits are achieved when the least active individuals become moderately active (27). The effectiveness of the intervention on PA levels was stronger for girls than for boys (16). In addition, the effect of the intervention on physical fitness was stronger for the least fit children at baseline. This finding seems promising. Firstly because research in adults has shown that increased risks associated with obesity are substantially lower when physical fitness is improved (28), it might be healthier to be fat and fit instead of slim but unfit (29). Secondly, because the physical fitness from the least fit children was improved by this school-based playground intervention, without focusing on the obese children.

The Eurofit test battery was developed in order to measure physical fitness in children, and is normally administered by PE teachers. From the literature it is known that at least the 20m shuttle-run and the hand grip test were reliable tests when administered by PE teachers, the standing long jump is less reliable (30). In our study the tests were administered by PE teachers and by PE students. All test leaders were trained to perform the test items following a standardised protocol including the instructions to the children, vocal encouragement and the scoring. The test leaders performed all tests with their group of children instead of performing one test item with all children. This was done to optimise the organisation of the testing, but this might have impaired the reliability of the test scores. To improve inter-rater reliability, test leaders were trained again prior the follow-up measurements and a standard set of equipment (tapping plate, sit-and-reach box, measuring tape, dynamo meter, SRT cd and stopwatches) was used at every school. To improve intra-rater reliability, test leaders were neither informed about norm scores for the specific age groups, nor about the baseline scores of the individual children, when testing at follow-up.

LIMITATIONS

The main weakness of this study is the lack of information on 1) habitual daily PA (such as PA during leisure time), and 2) body composition (such as body height and body weight and maturity level). A questionnaire on habitual daily PA was assessed at baseline and follow-up, but due to the large amount of missing data at follow-up, only baseline habitual daily PA was calculated. In the intervention group 55.1% (n=215) of the children was defined as physically inactive at baseline and 53.7% (n=187) in the control group. No information on body weight and body height was gathered, due to scheduled coinciding Health Service measurements at the participating schools. The Health Service measurements were not available for this study because of privacy laws. However, the population consisted probably of a high proportion of children with overweight, since they were recruited in low-SES neighbourhoods and distinctive for low-SES populations is a high prevalence of overweight (8). Studies have suggested a negative association between BMI and performance on fitness tests (31, 32). A higher fat mass has a negative effect on fitness measures that require moving against gravity, like the standing long jump (33). In addition, a higher fat mass could

enhance performance on strength measures, like the hand grip test (33). This is in agreement with our results: our study population scored better on the hand grip test and worse on the standing long jump.
There are several indications that heredity and maturation have more impact on fitness scores than PA levels (4, 34). In this study only the 9- to 12-year-old children were assessed for physical fitness and it remains unclear if the same positive effect could be expected in younger children as well. The effect of the PLAYgrounds intervention on PA levels was stronger for the oldest age group (10-12 years old) (12), which was the least active group before the intervention. In addition, PA levels in 6- to 12-year-old children seems to be poorly related to physical fitness (35). So, the dose-response relationship between PA and physical fitness is not clear and remains to be proven (36).

This paper shows the effect of a PA increase during recess (due to the PLAYgrounds programme) on physical fitness. Although intervention and control school were matched according to the number of pupils, playgrounds size and baseline use, it remains possible that other projects (like sports- or nutrition related actions) in the school or the content of the PE lessons are (partly) responsible for the changes in physical fitness. In addition, physical fitness is a complex combination of different constructs and whether the dose and the intensity of children's activity during recess were sufficient to increase fitness levels, remains unclear.

Despite several limitations, we conclude that the PLAYgrounds programme was effective in increasing some neuromotor fitness (eye-hand coordination, arm speed, running speed and agility) and cardiorespiratory endurance in both genderes. The increase in PA levels due to the PLAYgrounds programme was arguably not vigorous enough to improve other health-related fitness, such as muscular strength, muscular endurance and flexibility. The stronger effect for the least fit children however is promising, because of the major contribution of fitness in decreasing health risks. If schools could offer more PA moments a day, a greater effect from school-based PA interventions on physical fitness levels could be expected.

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CHAPTER 5
TRANSLATING THE PLAYGROUNDS PROGRAMME INTO PRACTICE: A PROCESS EVALUATION USING THE RE-AIM FRAMEWORK

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ABSTRACT

OBJECTIVES:

To present the results of the process evaluation of the PLAYgrounds programme, using the RE-AIM framework.

DESIGN:

This study provides information regarding Reach, Adoption, Implementation and Maintenance.

METHODS:

The PLAYgrounds programme promotes increasing levels of physical activity in 6- to 12-year-old children and was evaluated using the RE-AIM framework in 4 intervention schools. Data collection consisted of a physical activity questionnaire with children (n = 765, Reach), SOPLAY observations (Implementation and Maintenance), questionnaires on the satisfaction of the implemented elements with teachers (n = 59) and children (n = 730, Implementation) and interviews for increased depth of information. In addition a simple counting of participating schools, describing of non-participating reasons and characteristics of the schools were documented (Adoption).

RESULTS:

Reach of the target population (i.e. inactive children) was 60.7% (n = 464) and the target population was representative for populations in low-SES neighbourhoods. The PLAYgrounds programme was adopted by 4 schools (80%), at which 5 (from 7) programme elements were successfully implemented. At 18 months follow-up, 3 of those 5 elements were completely maintained.

CONCLUSION:

Adoption, Implementation, and Maintenance proved to be very high. Most likely due to the PLAYgrounds programme being a complete intervention package that included financial, material, and staff support. Therefore, it is recommended to retain this high level of support when introducing the PLAYgrounds (or any other intervention) programme in schools. In the future it would be recommended to evaluate the PLAYgrounds programme on maintenance in schools where the key person is employed at the school and funding is not available.

INTRODUCTION

Worldwide, only one third of all children meet the daily physical activity (PA) recommendations (1, 2). This is troublesome, because inactivity has been shown to be associated with different negative health consequences, such as coronary heart disease (3) and obesity (4). Therefore, promoting physical activity (PA) in children is a major public health priority.

Schools have been identified as logical places to promote PA in children, with children spending a large part of their regular days in school (5) and the possibility to reach children at all socioeconomic levels (6). In an effort to use these possibilities of schools, a playground intervention (PLAYgrounds) was developed to increase PA levels during recess. The intervention was based on an ecological approach, which was accomplished by a change of the physical and social environment. In order to increase the effectiveness, different effective components from earlier playground studies were implemented, i.e. time-management (7), playground markings (8, 9), provision of play equipment (10, 11), and adult supervision and encouragement (12). Beside those elements, supporting PE lessons were part of the PLAYgrounds programme to provide a stimulus on the long-term (13).

Previous playground studies all provided an evaluation of the effectiveness of the intervention, though recently the importance of evaluating the context in which interventions are implemented has been identified as critical (14). Above all, PA efficacy studies are evaluated under optimal conditions and the intended end-users in real-world settings might be less motivated after the intervention period has ended and external supports are withdrawn (15). If intervention programmes are not adopted to an adequate extent and then maintained, it is unlikely that these programmes will have any impact on public health. To evaluate research translation (16), the RE-AIM (17) model provides guidance. This is a systematic model, which could be used to guide the evaluation on the external validity of the intervention, i.e. the validity in real-world settings (18). Austin et al., (19) used the RE-AIM model to evaluate an existing effective playground intervention (8) and provided useful information on the translatability of the intervention.

As the effectiveness of the PLAYgrounds programme is evaluated in another paper (20), the aim of this paper was to examine the barriers and success factors of translation of the intervention into practice. The RE-AIM model was used to guide this evaluation, with the focus on Reach, Adoption, Implementation and Maintenance.

METHODS

This evaluation is part of a controlled trial on the effectiveness on PA levels of the PLAYgrounds programme in primary school children aged 6-12 years (20). All participating schools were located in the west of Amsterdam, a low socioeconomic area. The schools are united in a board (STWT) and this board has a partnership with the Academy for Physical Education (ALO) on student internships, which are focused on teaching PE and promoting health. At each school an oral presentation was given about the aim, benefits and organisation of the intervention.

Intervention and control schools were matched according to the number of pupils, playground size and the usage of the playground before the start of the intervention. PA levels prior to the intervention were assessed by the observation method SOPLAY (22). There was no significant baseline difference in energy expenditure at the playgrounds in the intervention and control group, which was respectively 0.075 kcal/kg/min (SD 0.01) and 0.082 kcal/kg/min (SD 0.02) (i.e. 4.5 and 5 METs, light intensity PA).

The intervention group received the PLAYgrounds programme for one school year (ten months, September 2009-June 2010), while the control group followed their regular routine. Parents gave their approval for the participation of their children following passive informed consent. The study design, the procedures and the informed consent procedure were approved by the Medical Ethics Committee of the VU University Medical Centre (NTR2386).

A full description of the intervention has been published elsewhere (21). In short, the intervention consisted of physical alterations of the playground, each tailored to each school, by which different areas for different games were created (for example a throw and catch area and a soccer field). Some of these areas were defined as hotspots, i.e. places where the majority of children would like to play. Through hotspot management all children were able to play at these popular areas. Additional play space per child was created through altered recess time management, reducing the number of children on the playground at any given time.

Table 1. Outline of the elements of the RE-AIM model, the measurement methods and the outcome measures

Element	Definition	Outcome measure(s)	Method(s) of Assessment
Reach	Participation of the target population	Percentage of children who are inactive	Questionnaire on daily PA levels providing the number of children who do not meet the guideline divided by those who meet the guideline
	Representativeness of the participating population	Characteristics of the participating population compared to comparable low-SES neighbourhoods	Ethnicity and classification of weight for both populations, provided by the Municipal Health Services
Effectiveness	Outcome measure: PA levels during recess	Energy expenditure during recess	SOPLAY observations
Adoption	Participation rate of the invited schools	Schools that were willing to participate in the PLAYgrounds programme	1. Number of schools that participated divided by those who declined x 100% 2. Non-participation reasons
	Representativeness of settings	Participating school's characteristics compared to data on non-participating schools	1. Number of children 2. Average number of children per school 3. Teachers to children ratio 4. Playground size 5. Playground lay out 6. Number of schools that participated in other health projects
Implementation	The extent to which participating schools implemented the different elements of the programme	Number of schools that implemented the intervention elements	SOPLAY observations, elaborated with quantitative data on programme elements at F1 and F2.
	Satisfaction on the different elements of the programme	Qualitative data on satisfaction on the implemented elements	Self-administered questionnaire and interviews at F1 and F2
Maintenance	The extent to which schools maintained the implemented elements of the PLAYgrounds programme	Number of schools that maintained the implemented elements	SOPLAY observations, elaborated with quantitative data on programme elements at F3.

F1 = Follow-up 1 (5 months), F2 = Follow-up 2 (10 months), F3 = Follow-up 3 (18 months)

Active usage of the playground was encouraged through the provision of play equipment, through supporting PE classes with playground activities and monthly themes, and through supervision and encouragement by teachers and parents, who participated in activities. Each class received a box with playground equipment, which consisted of throw-and-catch equipment, ropes, balls, juggling equipment and equipment for different tag games. Themes of activities were scheduled to provide a new stimulus every month and the regular PE lessons presented ideas on how to use the playground and available equipment corresponding to these themes. The teachers were scheduled to play together with the children once a week and parents were invited once a month to join the children at the playground.

The RE-AIM model was used to evaluate the translatability of the intervention. Table 1 shows an outline of the elements of the model, the outcome measures, as well as the methodology employed to register the required data. The current evaluation focused on Reach, Adoption, Implementation and Maintenance. Effectiveness was evaluated in a separate analysis (20).
Data collection consisted of different methods to address all RE-AIM components (Table 1). Reach was defined as the representativeness of the study population, and was described by a comparison of characteristics to a population of other low-SES neighbourhoods in Rotterdam, a city comparable to Amsterdam with regard to population and demographics. The Rotterdam Municipal Health Service provided information on inactivity, ethnicity and classification of weight, for their population. The Municipal Health Services of Amsterdam provided information on the classification of weight and ethnicity was derived from the school register. At the start of the school year (September 2009), all children aged 9-12 years old completed a PA questionnaire. The questions and methodology employed are used as the standardised indicator for PA in youth in the Netherlands and have been used in previous research on PA promotion (23). It includes in total 6 questions about the frequency and duration of PA in leisure time and sport participation during the last previous week. Leisure time was defined as after school hours and weekend hours, sport participation was defined as a structural weekly lesson at a sports club.

Adoption was defined as the participation rate of the invited schools and in order to get insight in the barriers to adopt the programme, non-participating reasons were documented. In addition, characteristics of the schools were described to define the representativeness of the settings, such as the number of children, playground size and layout (existence of playground markings).
In order to measure the Implementation and Maintenance, the SOPLAY observation protocol (22) was used. Besides a quantity measure (to determine PA levels at baseline and during the intervention) the protocol also provides information about aspects related to the social environment. Observations were further elaborated with quantitative data on programme elements, such as time-management and hotspot-management. After 16 hours of training at different playgrounds an inter-observer agreement of 88-96% was obtained between two observers (the researcher and the internship student at the different schools). The playground was observed as a whole every 5 minutes from left to right. A total of three observations per school were done (at follow-up 1, 2 and 3, i.e. 5, 10 and 18 months). The number of schools that implemented and/or maintained the different elements of the programme was documented.

The teachers and the children (9-12 years old) from the intervention schools completed a questionnaire on satisfaction at follow-up 1 and 2.

The answers of the questionnaire were organized on a 5-point Likert scale. The questions for the teachers were focused on the practical implications of the programme, the amount of guidance and interference, number of arguments between children and whether the PLAYgrounds programme could become standard in the school routine. Both children and teachers were asked for their opinion on the restructuring of the playground, the play equipment and the supporting PE programme. Children were also asked about the amount of joy and about their perception of being stimulated into becoming more physically active. The two upper answer categories were combined, as well as the two lower categories to describe the results of the questionnaire in percentages of satisfaction on implementation.

In order to get a greater depth of information derived from the questionnaires, interviews with 6 teachers (1 per grade) and with three different age groups, consisting of 8 randomly chosen children per group (total of 24 children) were held at the same follow-up stages as the questionnaire.

RESULTS

The schools (n = 15) that were invited to the PLAYgrounds programme consisted of 4540 children. The study population (a total of 4 intervention schools) consisted of 1155 children at the start and 1094 children at the end of the school year. A total of 765 children (only the 9- 12-year-old children) completed the PA questionnaire at the start of the school year, from which 60.7% (n = 464) was defined as physically inactive. Our study population consisted of 70.6% children with immigrant parents and a high percentage of overweight (30.7%). In Rotterdam, 63.2% of the children were physically inactive, 69.0% of the children had immigrant parents and 29.0% was overweight.

The Effectiveness of the intervention is published in another paper (20), but presented here in short form. Recess energy expenditure at the intervention schools (as measured through SOPLAY observations) was 0.105 kcal/kg/min (SD 0.01) (i.e. 6 METs) after follow-up, which was significantly different ($p < 0.01$) from the control group 0.074 kcal/kg/min (SD 0,01) (i.e. 4 METs)). These results show an increase from light intensity PA to moderate intensity PA, with 77.3% of the children engaging in moderate to vigorous intensity physical activity (MVPA).

A total of 15 schools were invited to enrol in the intervention, from which 10 schools responded positively (66,7%). Since intervention and control schools were matched, five schools adopted the programme. After the working group meetings, 80% (4 of the 5) started the actual preparation of the intervention. The five schools that responded negatively to the invitation declared they had the following non-participating reasons: (a) their playground already was restructured by the Nike-zone

Table 2 Characteristics of the participating and non-participating schools

	Participating schools (n=9)	Non-Participating schools (n=5)	School that did not start the preparation (n=1)
Number of children	2620	1591	329
Average number of children per school	291	318	329
Teachers to children ratio (mean, SD)	1:19.4 (2.5)	1:22.2 (1.6)	1:23.0
Playground			
- Size in m2 (mean, SD)	850 (50)	900 (20)	870
- Lay out (number of schools with playground markings)	2/9	2/5	0/1
Number of schools that participated in other health projects	4/9	2/5	0/1

SD = standard deviation

foundation (2 of the 5), (b) the school was enrolled in other PA programmes and therefore had a lack of time (2 of the 5), (c) they thought their children were physically active enough (1 of the 5). Table 2 (on previous page) shows the representativeness of the participating schools. The non-participating schools consisted on average of more children per school (318-291) and had a higher teacher to children ratio (1:22-1:19). Playground size and lay-out as well as the number of schools that participated in other health projects were comparable. In order to present all data, the characteristics of the school that did not start the preparation are presented in Table 2 in a separate column.

Table 3 shows the Implementation at follow-up 1 and 2. Questionnaires on satisfaction were completed by 744 children and 60 teachers at the five month follow-up and by 730 children and 59 teachers at the ten month follow-up. The restructuring of the playground, the time-management and the hotspotmanagement were completed by all schools (4 of the 4). The restructuring was accepted by 80% (n = 584) of the children and 100% (n = 59) of the teachers. All teachers (n = 59) were positive about the recess time-management and the hotspot-management. For example, soccer did not dominate the school playground anymore and therefore a variety of games were played compared to the control schools, where limited space was left for other games or for more timid children. The high level of satisfaction was associated with a lower number of arguments between children (1-2 per recess, compared to 6-9 per recess at the control schools) and (for teachers) the decrease in guidance that was required through the school year.

Provision of play equipment was implemented by all schools (4 of the 4) and the observations showed that the box with play equipment contributed to the variety of games that were played compared to the control schools (15 versus 3). At follow-up 1, the box was used by all teachers (n = 59) and by 90% of the children (n = 670). The children that did not use the box stated that they played games for which they did not need any equipment. At follow-up 2 one school did not use the box with play equipment as frequently anymore as at follow-up 1, because teachers and children stated that there was not enough variation in equipment throughout the school year.

At all schools (4 of the 4) the supporting PE programme had started. PE teachers stated that the programme fitted well into the PE curriculum. The observations confirmed that less time was spent on rules and organisation at the playground compared to the control schools (30 s-1.5 min compared to 2-6.5 min). Classroom teachers felt that the supporting PE programme was motivational for the children (the theme of the month in particular). Children stated that they liked recess time more, because of clear game rules and

Table 3 Implementation and maintenance of the different elements of the PLAYgrounds programme

Intervention schools n=4	Implementation Follow-up 1 (5 months)	Implementation Follow-up 2 (10 months)	Maintenance Follow-up 3 (18 months)
Restructuring of the playground	4/4	4/4	4/4
Time-management	4/4	4/4	4/4
Hotspot-management	4/4	4/4	2/4
Play equipment provision	4/4	3/4	2/4
Supporting PE programme	4/4	4/4	4/4
Participation of teachers	3/4	2/4	2/4
Participation of parents	1/4	1/4	1/4

better practised motor skills, which they needed for the activities on the playground.

At three schools teachers played together with the children every week at follow-up 1. At follow-up 2 there was a decrease in number of schools where the teachers played together with the children on a weekly basis (2 of the 4). Teachers stated that they needed recess time to get some rest from teaching and to talk to other teachers, rather than playing together with the children. At one school only, parents participated during the monthly recess invitation (same for follow-up 1 and 2) and teachers stated that they were disappointed in the parent participation. Children stated that they were positively surprised and encouraged by the teacher and parent participation.

Due to the playground programme, 85% of the children stated that the amount of joy was higher. Almost all children (91%) felt that they were more encouraged to be physically active and mentioned different reasons for the encouragement: the restructuring of the playground, the play equipment, the PE lessons and the adult participation.

Most implemented elements were maintained throughout the next school year (Table 3). Hotspot-management and the box with play equipment were still in use (4 of the 4), but in some schools in some extent undisciplined (2 of the 4). Teacher participation and (2 of the 4) and parent participation (1 of the 4) were the least sustainable components of the PLAYgrounds programme.

DISCUSSION

The aim of the PLAYgrounds programme was to stimulate PA levels of children. The effectiveness of this intervention is described in another manuscript (20). The PLAYgrounds programme was associated with an increase in recess PA levels from light intensity PA to moderate intensity PA. Recess in the Netherlands lasts 15 minutes per day. As such, the intervention could contribute 25% to the Dutch guidelines for PA. The current evaluation aimed to provide information on the barriers and success factors surrounding the implementation of this effective intervention.

The percentage of children who were inactive (assessed with the PA questionnaire) could be higher, because self-reported questionnaires are known to be vulnerable to recall biases and social desirability (24). However, our study population was representative for the population of children in low-SES neighbourhoods (25). In order to promote a broader dissemination of the intervention, the Adoption, Implementation and Maintenance were evaluated and these showed to be high.

The main reasons to adopt the programme were that the programme was offered to the schools as a complete intervention package including funding, support and research. This underlines the fact that schools are busy places where the core business is learning and less time remains for other intentions, like encouragement of PA (26). Two (of three) reasons for not adopting the programme were involvement in other PA programmes. Therefore, tuning with other health programmes (from which an overflow is offered to schools) could enhance the adoption. At the school that did not complete the preparations, the decision to adopt the programme was made top-down by the principal, whereas at the other schools it was discussed with the teachers first. Teacher involvement is highly important for adoption of a programme (27). One method to accomplish this is to explain about the benefits of the intervention for the end-users, either in behaviour, costs or satisfaction (19).

The Implementation was evaluated by observations and by questionnaires and interviews with the end-users. Evidence derived from questionnaires and interviews has great practical significance, since the end-users provide information on their experiences (19). A limitation of our study is that the interview data collected was not audio recorded or corrected afterwards by the interviewers for accuracy. In addition, there was no coding or categorising into predetermined themes for analyses. Despite this limitation in methodology, the combination of these methods provided a full image of the barriers and success factors in Implementation and Maintenance of the programme.
The implementation of the different elements of the PLAYgrounds programme was successful, because the programme was not too complex and therefore did not consume too much time (28). At the start of the intervention, guidance was required to let the children get used to the new structure at the playground, the use of the box with play equipment and the hotspot schedules. After three months it was part of the new school routine and less guidance was required. Despite the simplicity of the programme, teacher training and support (28) was required to guide the classroom teachers in implementing the programme. The support was given by the internship student, who played a role in the supporting PE programme and who also was available at the playground (while the PE teacher had to teach during recess). This provided ample opportunities to pick up Implementation problems and apply educational measures.

The least successful elements were the teacher and parent participation. Encouragement from adults stimulates children to be more physically active and to maintain a higher level of PA (12). A recommendation would be to evaluate the programme with the teachers to keep everyone focused and convinced of their participation at the playground. Using a schedule of teacher duty would concede to the needs of the teachers for a coffee break. Perhaps parent participation is not a key factor in stimulating children to be more physically active during recess and therefore this element could be left out of the programme. On the other hand, parent participation once a month at the playground could inspire parents to play a variety of games with their children in leisure time. This could be necessary in order to stimulate children to meet the PA guidelines, since recess could only contribute up to 25% to the guidelines. In order to stimulate parent participation during recess, parents could be informed in a parent information meeting, by news letters and by a personal invitation from their own child.

After the intervention period had ended, most elements of the programme were maintained, probably because the schools received annual funding and support. Funding is an important factor to adopt (29) and to maintain an intervention (15), in this programme in particular, for well-kept playground markings and for replacing defective or lost play equipment. This provided an artificially high Maintenance of the PLAYgrounds programme, which was made possible by the partnership between the STWT (providing funding) and the ALO (providing an internship student) and might be lower when this partnership would not have existed. Working in partnership increases the knowledge, skills, and resources of the end-users (29), which was accomplished by the internship student.

Strategies to increase the Maintenance of the PLAYgrounds programme should include a key person who advocates the innovation (30). In this programme the internship student had this role and was of great value for the Implementation and Maintenance. Though in real-world settings, partnership in which funding and support is provided,

is not common. Therefore a key person from the school should be available. At the two schools that did not maintain the hotspot-management and provision of play equipment, no internship student or key person from the school was available. In the future it would be recommended to evaluate the PLAYgrounds programme in schools were the key person is employed at the school and funding is not available. The programme should then be integrated in the school system to be successful (31).

CONCLUSION

This paper provides useful information on the barriers and success factors of the dissemination of putting the effective PLAYgrounds programme into practice. Adoption, Implementation, and Maintenance proved to be very high. Most likely due to the PLAYgrounds programme being a complete intervention package that included financial, material, and staff support. Therefore, it is recommended to retain this high level of support when introducing the PLAYgrounds (or any other intervention) programme in schools. In the future it would be recommended to evaluate the PLAYgrounds programme on Maintenance in schools were the key person is employed at the school and funding is not available.

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CHAPTER 6
EFFECTS OF ACUTE BOUTS OF PHYSICAL ACTIVITY ON CHILDREN'S ATTENTION: A SYSTEMATIC REVIEW OF THE LITERATURE

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ABSTRACT
The aim of this review was to describe the effects of acute bouts of physical activity on attention levels of children. A systematic review was performed of English studies from searches in PubMed, Sportdiscus and PsycINFO from 1990 to (May) 2014 according to the PRISMA statement. Only prospective studies of children aged 4-18 years old were included, detailing acute effects of physical activity bouts with the primary outcome attention.

One reviewer extracted data on the study characteristics. Two reviewers conducted the methodological quality assessment independently using a criteria checklist, which was based on the Downs and Black checklist for non-randomised studies.

Overall the evidence is thin and inconclusive. The methodological differences in study sample (size and age), study design and measurement of attention make it difficult to compare results. There is weak evidence for the effect of acute bouts of physical activity on attention. More experimental studies with a comparable methodology, especially in the school setting, are needed to strengthen this evidence.

INTRODUCTION

Schools have been recognised as key settings for promoting physical activity (PA) in children, because children spend a large part of their regular days in school (13). Therefore, schools are frequently requested to implement different physical activity programs. However, schools have the primary priority to improve cognition and are under pressure to improve academic scores. This often results in additional time for cognitive learning and less time for physical education classes or recess (14). Nevertheless, Ahamed et al. (15) concluded that decreasing time spent in PA does not improve academic performance. Furthermore, a recent review concluded strong evidence for a significant positive relationship between PA and academic performance (16).

However, the evidence from this review is based on cross-sectional studies and does not give insight in the complex relationship between PA and academic performance. Fortunately, the literature-base on the acute effect of PA on the underlying cognitive processes of academic performance is growing. Hillman et al. (17) found in their review a positive effect of acute PA on brain health and cognition in children, but concluded it was complicated to compare the different studies, due to the different outcome measures (e.g. memory, response time and accuracy, attention, and comprehension).

Therefore, this review focuses on the sole outcome measure 'attention' as a mediator for cognition and achievement. Attention is defined as the ability to resist distraction. Attention acts as a 'gate' into working memory, regulating the flow of sensory information into conscious awareness (18). Attention is important for several aspects of learning and memory storage; attention is required when learning something (to encode the information) but also when recalling a memory (19). Deficits in attention are associated with poorer academic performance (20). To our knowledge, no systematic review on the acute effect of PA focusing on attention has been published. In this systematic review, experimental and observational studies examining the effect of acute bouts of PA on attention in children were included.

METHODS

REVIEW PROTOCOL

The PRISMA-statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions (21) was used as a guideline to conduct this review. Prior to the review, a review protocol was made in which pre-specified outcomes of primary interest, the methodology of data extraction on these outcomes and the methodological quality assessment was described (Additional file 1).

ELIGIBILITY CRITERIA

Population

Only prospective studies (experiments and observations) that were conducted with children were included in the review. In the protocol children were defined as the age group between 4 and 18 years old. Since the growth factor BDNF is also associated with metabolism (22) and behavioural disorders (e.g. ADHD) with inattentiveness, only studies with healthy participant groups were included. Studies with specific groups (e.g. children with obesity or diabetes 2, children with ADHD or depression) were excluded, as these characteristics may be confounders.

PA bout

Studies with a short PA bout (i.e. max. 45 minutes) and various levels of PA intensity were included. PA bouts could be performed during a physical education lesson, in-between lessons, at the playground, or as an energizer during class. The PA bouts could be performed with or without equipment or apparatus.

Outcomes

Only studies with an outcome measure of some sort of attention (e.g. attention, on-task behaviour, neuroelectric attentional performance) were included.

Studies that focused on other cognitive tasks, (e.g. short-term or long-term memory, successive processing etc.) were excluded.

INFORMATION SOURCES

Studies were identified by searching electronic databases (PubMed, Sportdiscus and PsycINFO) from 1990 to May 2014. The search consisted of three elements, which were combined in the final search strategy: (1) physical activity (i.e. physical activity, leisure activity, exercise, physical fitness, sport, cycling, walking and training) (2) attention (i.e. attention, on task performance, attentional performance, cognitive control, executive control, concentration) and (3) age (i.e. infant, child, and adolescent). Medical Subject Headings (MeSH) were available for physical activity (all synonyms), attention and age (all synonyms). MeSH terms and free text words were used in all databases (Additional file 2). In addition, a hand search was done in reference lists of identified studies for relevant literature.

STUDY SELECTION

All experimental and observational studies, which were full-text articles published after 1990 in English peer-reviewed journals were included. One reviewer (MJ) screened all titles and abstracts and in case of uncertainty, the full article was screened.

DATA COLLECTION PROCESS

One reviewer (MJ) extracted data on the study population, the study design, the PA bout, measure of attention, and on the main results. Two reviewers (MJ and EV) independently conducted the methodological quality assessment and disagreements were resolved by discussion. For this assessment a criteria checklist (based on the Downs and Black checklist for non-randomised studies (11) was used. This checklist consists of 27 items and contains items to assess the quality of the reporting, the external and internal validity of the study and the study power. The criteria answer format included 'yes' (1) and 'no' or 'unable to determine' (both coded 0). A criterion was scored as 'not applicable' (NA), when the criterion was not relevant for the study design.

One criterion needed clarification of interpretation before scoring the studies. The criteria 'Was compliance with the interventions reliable' was scored with '0' when no attempt was made to define the type, duration and level of intensity (for example with heart rate monitors) of PA. In order to establish the validity and proper use of this set of predefined criteria, the inter-rater agreement, expressed as Cohen's κ, was calculated.

RESULTS

STUDY SELECTION

The systematic literature search combined with hand searches revealed 537 studies. After excluding duplicates (n = 24), titles and abstracts of 513 studies were screened for eligibility, of which 12 were included in this review.

Figure 1 (on next page) shows the flow diagram of the selection process, with reasons for exclusions at each stage.

METHODOLOGICAL ASSESSMENT

In total 12 studies were screened on 25 criteria (Additional file 3). Table 1 (on next page) provides the methodological assessment for each individual study. The reviewers scored different on 33 of 300 items, equalling to a Cohen's κ of 0.74. This is considered reasonable to good (24). In 22 of the items, there was initial disagreement as to whether an item was described in the studies. In the other 11 items, reviewers disagreed; mainly regarding the representativeness of the study sample,

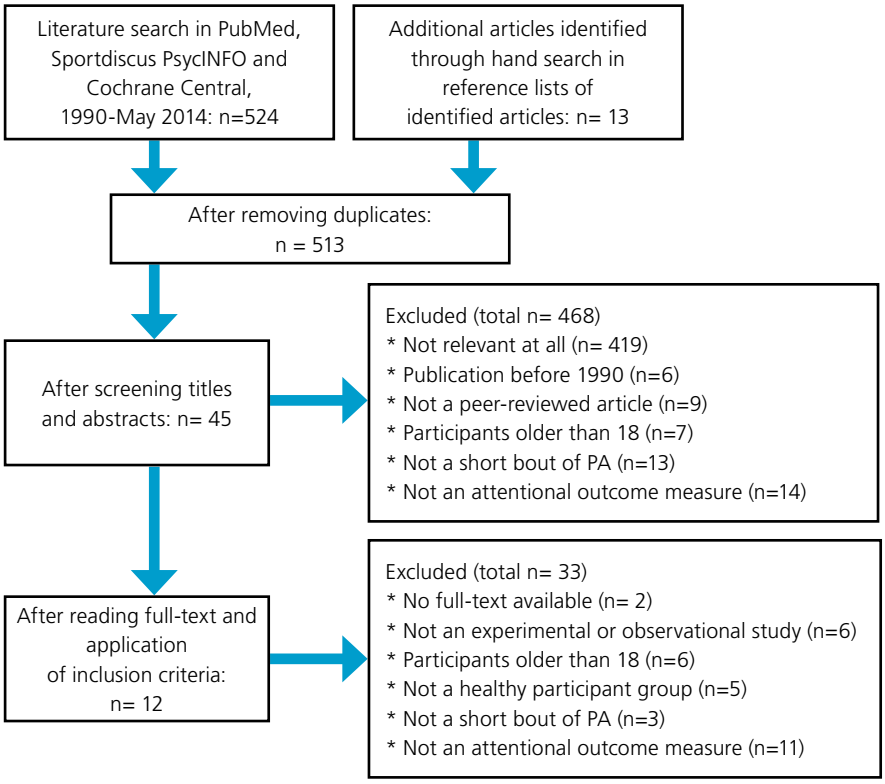

Figure 1 Flow diagram of the selection process

participant characteristics and possible confounders (e.g. ADHD, BMI, physical fitness). After discussing the differences, agreement was reached for all differences. A number of the disagreement issues are described below.

A '0' was given when no participant characteristics were given, but also when participant characteristics were only partly described. For example in one study (5) different important characteristics were given, but no information was available on BMI, level of intensity of PA or type of sport.
Type of sport could be a modifier for socioeconomic status. In one study (4) the intervention (coordinative exercises) was clearly described, but not the control condition. The control condition was described as 'teachers instructed the students to exercise at a moderate intensity without any specific coordinative request' and it remains unclear which exercises were performed that were not of coordinative character.
A note has to be made on the criterion 'Was an attempt made to blind study objects to the intervention they have received'. This criterion was scored '0' in every study and it must be noted that blinding participants from a PA intervention is practically impossible.

Table 1 Results of the methodological quality assessment

Criteria	#1 Raviv& Low, 1990	#2 Caterino & Polak, 1999	#3 Mahar et al., 2008	#4 Budde et al., 2008	#5 Cereatti et al., 2009	#6 Hillman et al., 2009	#7 Grieco et al., 2009	#8 Stroth et al., 2009	#9 Drollette et al., 2012	#10 Pirrie& Lode-wyk, 2012	#11 Pontifex et al., 2013	#12 Drollette et al., 2014
Objective	1	1	1	1	1	1	1	1	1	1	1	1
Main outcomes	1	1	1	1	1	1	1	1	1	1	1	1
Participant characteristics	0	0	0	1	0	1	1	1	1	0	1	1
Interventions of interest	0	0	0	0	1	1	0	1	1	1	1	1
Confounders described	0	0	0	1	1	1	0	1	1	0	1	1
Main findings	1	1	1	1	1	1	1	0	1	1	1	1
Random variability	1	1	1	1	1	1	1	1	1	1	1	1
Characteristics of lost to follow-up participants	0	0	0	0	1	1	0	1	1	0	1	1
Actual probability values given	1	1	0	1	1	1	0	0	1	1	1	1
Representative population	0	0	0	0	0	0	0	0	0	0	0	0
Representative participants	0	0	0	0	0	0	0	0	0	0	0	0
Blinding of participants	0	0	0	0	0	0	0	0	0	0	0	0
Blinding of test leaders	0	0	0	0	0	0	1	0	0	0	0	0
Control and intervention condition described (type, duration and level PA)	0	0	0	1	0	1	0	1	1	0	1	1
Length of follow-up same for intervention and control group	0	NA	0	1	NA	0	1	1	0	1	0	0
Statistical tests appropriate	1	1	1	1	1	1	1	1	1	1	1	1
Compliance to intervention measured	0	0	0	1	1	1	0	1	1	1	1	1
Main outcome measures accurate	1	1	1	1	1	1	1	0	1	1	1	1
Intervention and control group recruited from the same population	1	1	1	1	0	0	1	0	1	1	0	1
Intervention and control group recruited over the same period of time	1	1	1	1	0	0	1	1	1	1	1	1
Randomisation	0	1	1	1	0	0	1	1	1	0	1	1
Randomisation assignment concealed	0	0	0	0	0	0	0	0	0	0	0	0
Adjustment for confounding	0	0	0	0	0	0	0	1	0	0	0	0
Losses to follow-up taken into account	0	0	0	0	1	1	0	1	0	1	0	0
Power analysis provided	0	0	0	0	0	0	0	0	0	0	0	0
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#9	#12
Total score	9	10	9	15	11	14	12	15	16	13	15	16
Percentage (%)	36	40	36	60	44	56	48	60	64	52	60	64

Overall, the studies of Drollette et al. (9), and Drollette et al. (12) had the highest methodological score. From the studies in a school setting Budde et al. (4) had the highest score. The study of Drollette et al. (9) reported maintenance of attention level after exercise compared to seated rest and the study of Drollette et al. (12) reported an improvement in attention level. Budde et al. (4) reported a positive effect on attention through coordination exercises at a moderate PA level as compared to a normal PE lesson of the same intensity level.

STUDY CHARACTERISTICS

Table 2 provides a summary of the studies included in the review with regard to the main characteristics.

Ten experimental studies (1; 2; 4; 5; 6; 8; 9; 10; 11; 12) and two observational studies (3; 7) were included, with in total 916 participants in the age range of 7 to 17 years old.

Six studies were performed in a laboratory (5; 6; 8; 9; 11; 12) and six in a school setting. Of these six studies, three studies (1; 2; 10) examined the difference between a classroom task and an active lesson. One study (4) examined the difference between two active lessons with different activity types, one study (3) examined the effect of energizers (i.e. short bouts of PA in the classroom) and one study (7) examined the effect of exercise during a cognitive task.

Table 2 Main characteristics of the included studies

# / ref. number	Study	Country	Population (n; age)	Design; setting	PA assessment
1	Raviv & Low, 1990	Israel	n=69; n boys and girls unknown; 11-12 yrs	Experiment; schoolsetting	None
2	Caterino & Polak, 1999	USA	n=177; n boys and girls unknown; 7-10 yrs	Experiment; schoolsetting	None
3	Mahar et al., 2006	USA	n=243; n boys and girls unknown; 8-11 yrs	Observation of 12 weeks Daily intervention; schoolsetting	Number of steps (pedometer)
4	Budde et al., 2008	Germany	n=99; 80 boys, 19 girls; 13-16 yrs	Experiment; schoolsetting	HR
5	Cereatti et al., 2009	Italy	n= 24; 24 boys, 0 girls; 14-17 yrs	Experiment; laboratory	HR
6	Hillman et al., 2009b	USA	n=20; n boys and girls unknown; 9-10 yrs	Experiment; laboratory	HR
7	Grieco et al., 2009	USA	n= 97; n boys and girls unknown; 7-8 yrs	Observation of 1 school year Intervention 4 days a week; schoolsetting	Observation of PA level; Number of steps (pedometer)
8	Stroth et al., 2009	Germany	n= 33; 20 boys and 13 girls; 13-14 yrs	Experiment; laboratory	HR
9	Drollette et al., 2012	USA	n= 36; 16 boys and 20 girls; 9-11 yrs	Experiment; laboratory	HR
10	Pirrie & Lodewyk, 2012	Canada	n= 40; 22 boys; 18 girls 9-10 yrs	Experiment; schoolsetting	HR (in half of the children)
11	Pontifex et al., 2013	USA	n=20 (other 20 non-eligible: children with ADHD); 14 boys, 6 girls; 8-10 yrs	Experiment; laboratory	HR
12	Drollette et al., 2014	USA	n= 40; 13 boys and 27 girls; 8-10 yrs	Experiment; laboratory	HR

USA = United States of America; n = number of participants; yrs = years old; PA = physical activity; PE = physical education; vs = versus; min = minutes; HR = heart rate; HRR = Heart Rate Reserve; MVPA= moderate to vigorous intensity PA; RT = reaction time; ADHD = attention-deficit/hyperactivity disorder

The PA bouts differed amongst studies in type, duration and level. In seven studies an aerobic type of PA was performed (2; 5; 6, 8; 9; 11; 12), in one study coordinative exercises were compared to a normal PE lesson (PA type of exercises unknown) (4) and in four studies the PA type was not specified (1; 3; 7; 10).

The duration of the PA bout varied from 10 to 45 minutes. Assessment of PA level was done in all six laboratory studies (5; 6; 8; 9; 11; 12) and in two studies performed in the school setting (4; 10).
The PA level varied around 60% of the maximum heart rate in all six studies, which corresponds to a moderate intensity level of PA. This was either theoretically estimated by 220-age (4; 5) or measured by a direct VO2max test (6; 8; 9; 10; 11; 12).
Attention was measured by different measures. In the studies performed in a school setting, four different measurements were done (D2-test, observation of on-task behaviour or time on task, the Woodcock-Johnson test of Concentration and the Cognitive Assessment System (CAS)). In the laboratory studies, the measurement of attention was more comparable; either a computerized visual attention task or (modified) flanker tasks were used.

The main results were inconclusive. Five of the six laboratory studies found a significant effect on cognitive control of attention. One laboratory study

Table 2 continued

# / ref. number	PA type; duration; level	Attention measure	Main results
1	PE class vs science class; unknown; unknown	D2 (visual selective attention, information processing speed, ability to concentrate)	Higher scores at the end of lesson, no significant difference between classes (p=0.47)
2	Stretching and aerobic walking vs classroom task; 15 min.; unknown	Woodcock-Johnson Test of Concentration	Significant difference only for 9-10 year old children (p=0.05)
3	Energizers; 10 min; unknown	Observation of on-task behaviour	Significant improvement (8%, p=0.017), low performers 20%
4	Normal PE class vs coordinative exercises; 10 min; moderate	D2 (visual selective attention, information processing speed, ability to concentrate)	Significant improvement after coordinative exercises (p<0.01)
5	Bicycle ergometer; duration unknown (as long as attention measure lasted); 60% HRR	Computerized visual attention task	Significant improvement in RT (p<0.023)
6	Treadmill; 20 min; 60% HR max	A modified flanker task (inhibitory control), combined with EEG	Effect on cognitive control of attention; Significant improvement of accuracy (p=0.008), no improvement in RT
7	PA during classroom task; 10-15 min; MVPA	Time on task (TOT)	No decrease of TOT after PA (significant difference with inactive lesson, p<0.001)
8	Bicycle ergometer; 20 min; 60% HR max	A modified flanker task (task preparation and response inhibition), combined with EEG	Acute moderate PA was not related to executive control (attention among others; p>0.76)
9	Treadmill; 20 min; 60% HR max	A modified flanker task (inhibitory control)	Effect on attention after walking, not during walking. Maintenance of accuracy (p=0.01) after PA vs. seated rest, not in RT
10	45 min PE lesson; 28-30 min in MVPA (≥65% HR max)	Cognitive Assessment System (planning, attention, simultaneous processing, successive processing)	No significant effect on attention
11	Treadmill; 20 min; 65-75% HR max	A modified flanker task (inhibitory control), combined with EEG	Effect on cognitive control of attention; Significant improvement of accuracy (p=0.011), no improvement in RT. Better improvement in children with ADHD
12	Treadmill; 20 min; 60-70% HR max	A modified flanker task (inhibitory control), combined with EEG	Effect on cognitive control of attention; Significant improvement of accuracy (p=0.003), no improvement in RT. Better improvement in low performers

(5) found a significant improvement in reaction time, one study showed a maintenance of accuracy of task (9) and three studies showed a significant improvement on accuracy on the task and not on reaction time (6; 11; 12).
Regarding the studies in a school setting, there was no overall significant difference in attention after an active lesson and after a classroom lesson.

However, analyses of subgroups showed significant results. Caterino and Polak (2) found a significant effect of PA only for 9- to 10-year-old children and Budde et al. (4) found a significant effect only after coordinative exercises (for example bouncing a ball, while balancing). Performing energizers led to a significant improvement of time on task (i.e. the time in verbal or motor behaviour that followed the class rules and was appropriate to the learning situation) after performing the energizers (3), but when these energizers were performed during a classroom task, no improvement was found (7).
It must be noted that no study provided a power analysis and therefore the lack of significant results can be caused by insufficient power to reject the null hypothesis.

DISCUSSION

In this systematic review, 12 experimental and observational studies were included that examined the effect of acute bouts of PA on attention in children. Due to methodological differences in study sample (size and age), study design, and measurement of attention, it was difficult to compare results. These differences are discussed below.

POPULATION

Sample characteristics between studies differed and made it difficult to compare the results. For example the age range between studies ranged from 7 to 17 years. Caterino and Polak (2) found significant effect of PA only for 9- to 10-year-old children, no effects were found for 7- to 8-year-old children, indicating the differences in outcomes between ages and the difficulty in comparing the various studies included. Children undergo rapid, process specific changes in cognitive development. Thus, age may influence potential mechanisms for the effects of PA on attention. There was no evidence of influence of gender on the acute effect of PA on attention. However, most studies did not examine gender differences.

PA BOUTS

In most studies an aerobic type of PA was included, of which 4 (from 7) found a positive effect on attention. Budde et al. (4) compared a PA bout consisting of coordinative exercises to a normal PE lesson of the same intensity level and found a significant difference between the two PA bouts in favour of the coordinative exercise condition. Coordinative exercises might lead to preactivation of parts of the brain, which are also responsible for mediating functions like attention. This explanation is further supported by a study on cognitive flexibility, which demonstrated that cortical transcranial magnetic stimulation manipulates subcortical cognitive functions (25). Thus, type of activity may have influence on the acute effect of a PA bout on attention.

The length of PA bouts differed among studies, varying between 10 to 45 minutes. In the majority of studies that included a short PA bout with a maximum of 20 minutes, a significant effect of PA on attention was found. In contrast, in the study from Pirrie and Lodewyk (10) no effect was found after a 45 minutes PA bout. This indicates that the duration of PA may influence the effect of PA on attention.

Overall all studies included a short bout of moderate intensity PA. In the study of Pirrie and Lodewyk (10), 67% of the PA bout was strenuous (>65% HRmax).

This study showed no effect of PA on attention. Arguably, intensity of PA influences the effect of PA on attention and the effect of PA on attention may follow an inverted U relationship.

The inverted-U-hypothesis (26) states that cognitive performance is optimally enhanced with a moderate level of arousal (27) and that PA can increase arousal level. The relation between the intensity of PA and arousal in mice follows an inverted U, with an optimum at moderate PA intensity (28). Also for human adults, the optimal level of arousal seems to be at moderate intensity PA (29). Arguably, this optimal level is the same in children because despite the fact that children undergo rapid, process-specific changes in cognitive development, attentional control is fully developed by the age of 7 (30).

There are several suggested mechanisms for a positive association between PA and cognitive skills, which are mainly explained by neuropsychological improvements (e.g. increased blood flow to the brain (31), increased levels of hormones which results in a reduction of stress (32), and increased growth factors for creating new cells (33). Due to these growth factors, attention, stimulus selection, and decision making are improved (34). BDNF is one of these growth factors and is mainly found in the pre-frontal cortex, basal forebrain and hippocampus (34) where decision making takes place (i.e. priority is given to important information and distraction is eliminated).

OUTCOME MEASURES

Although this systematic review focused on one outcome measure i.e. attention, it remains difficult to compare the outcome of the studies. The definition of attention is not unambiguous.
Theoretically a distinction is made between selective attention (the ability to complete a task without being distracted by other stimuli that are being presented), divided attention (the ability to complete multiple tasks at once) and sustained attention (the ability to stay focused on a task for a long time) (35). In addition, attention is always involved in other cognitive processes, which makes the measurement of attention difficult (35). Therefore, a variety of attention tests are available, which also reflects the differences in methodology of the studies in this review.

In the studies performed in a school setting, four different measurements of attention at a behavioural level were employed; (a) the D2-test, which measures visual selective attention, information processing speed and the ability to concentrate; (b) observation of on-task behaviour or time on task, which is a measure of sustained attention; (c) the Woodcock-Johnson Test of Concentration, which measures selective attention; and (d) the Cognitive Assessment System (CAS), in which the attention test was a Stroop-like task, i. e. a measure of selective attention and inhibitory control.

In the laboratory studies, the measurement of attention was done at the neural level; either a computerized visual attention task, which measures reaction time and accuracy; or a (modified) flanker task, which measures response speed, accuracy and changes in the speed and accuracy of information processing. In these tests, inhibitory control is an important factor.
In four laboratory studies, the modified flanker task was combined with EEG. An EEG shows neuropsychological changes, which are reflected in the amplitude and the latency of the P3 (an event related potential (ERP) component elicited in the process of decision making). A higher amplitude reflects a greater resource accuracy by a greater attentional allocation (36) and an increased latency reflects longer processing time (37). The results from the studies using a flanker

task showed a positive effect from a short PA bout on attention, except for the study from Stroth et al. (8). However, Hillman et al. (17) stated that the EEG measurement of Stroth et al (8) was not performed at the most appropriate region of the scalp.

SUMMARY OF EVIDENCE

Overall the evidence is weak and inconclusive due to methodological differences. Although we focused on one outcome measure, the methodological differences in study sample (size and age), study design, and measurement of attention make it difficult to compare results. Although the laboratory studies are more comparable, there is limited generalizability of the results to the school setting. The few studies that have been conducted within a school setting are less comparable, due to differences in methodology. Although laboratory based research can allow for greater scientific rigour than field based research, more methodologically comparable studies in the school setting are needed to strengthen this evidence.
Therefore, it is necessary to create a robust knowledge base about the duration and intensity of the acute bout of PA that influences the effect on attention and also about the measurement of attention in a school setting.

LIMITATIONS

This study concerns the results of a systematic review on studies which evaluated the effect of a single acute bout of PA on attention. A limitation of this review is, that no meta-analysis could be performed. This might have been possible for the laboratory studies, in which the measurements were comparable.
Furthermore, the measurement of the quality of the studies depends on the interpretation of the reviewers and the choice for the checklist. A different checklist could have given different results.
Although we screened reviews and reference lists, the possibility exists of publication bias, which leads to an overestimation of a potential positive effect from physical activity on attention. On the other hand, a few studies with no effect on attention were also selected for this review.
The synthetic approach could give a false impression of homogeneity, in particular with regard to measurement of intensity of PA and attention. Provision of the details in the tables will give insight into heterogeneity.

Additional file 1: Review protocol
Additional file 2: Full search strategy
Additional file 3: Criteria checklist for the methodological assessment

Additional files are available on request.

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CHAPTER 7
A SHORT PHYSICAL ACTIVITY BREAK FROM COGNITIVE TASKS INCREASES SELECTIVE ATTENTION IN PRIMARY SCHOOL CHILDREN AGED 10-11

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ABSTRACT

IMPORTANCE

Evidence for an acute effect of physical activity on cognitive performance within the schoolsetting is limited. The purpose of this study was to gain insight into acute effects of a short physical activity bout on selective attention in primary school children, specifically in the schoolsetting.

METHODS

Hundred and twenty three 10-11 years old children were participating, 49.6% girls. All children engaged in four experimental breaks in random order: 1 hour of regular cognitive school tasks followed by a 15 minute episode with the following conditions 1) 'no break' (continuing a cognitive task), 2) passive break (listening to a story), 3) moderate intensity physical activity break (jogging, passing, dribbling) and 4) vigorous intensity physical activity break (running, jumping, skipping). Selective attention in the classroom assessed by the TEA-Ch test before and after the 15 minute break in each condition.

RESULTS

After the passive break, the moderate intensity physical activity break and the vigorous intensity physical activity break attention scores were significantly better ($p<0.001$) than after the 'no break' condition. Attention scores were best after the moderate intensity physical activity break (difference with no break=-0.59 sec/target, 95% CI:-0.70;-0.49).

CONCLUSION

The results show a significant positive effect of both a passive break as well as a physical activity break on selective attention, with the largest effect of a moderate intensity physical activity break. This suggests that schools could implement a moderate intensity physical activity break during the school day to optimize attention levels and thereby improve school performance.

INTRODUCTION

Because children spend a large part of their regular days in school, schools have been recognized as key settings for promoting physical activity (PA) in children (1). However, the primary priority for schools is to provide a tailored curriculum in order to help children to develop their knowledge, understanding and cognitive skills. These two statements seem contradictory. However, research has shown that additional time for cognitive subjects does not necessarily lead to an improvement in academic performance (2). Interestingly, less time for cognitive subjects and more time allotted to PA also do not necessarily reduce academic performance (3). A recent review revealed evidence for a significant positive relationship between PA and academic performance (44).

In addition to the described positive relationship between PA and academic performance, the literature on the acute effect of PA on cognition is expanding. A meta-analysis by Mc Morris & Hale (5) showed positive significant effects of moderate intensity exercise and a possible negative effect of high intensity exercise. Also in children, acute and chronic exercise has shown positive effects on cognition (6, 7).
However, there is a lack of knowledge about the effect of different PA intensities on cognition in children.

There are several mechanisms which could explain an effect of acute aerobic types of PA on cognition, such as an increased blood and oxygen flow to the brain (8), and increased hormone levels (9) argued to lead to stress reduction.

However, the evidence from the acute effect of PA on central executive tasks (e.g. selection, initiation, and termination of processing routine) is more robust than the effect on attention tasks (5). Attention is defined as the ability to resist distraction. Selective attention is the ability to process specific target information while ignoring irrelevant information (10), resulting in increased efficiency, improved sensory discrimination and is helpful for memory. Attention is important for several aspects of learning and memory storage; attention is required when learning something (to encode the information), but also when recalling a memory (11). Deficits in attention are associated with poorer academic performance (12).

Moreover, the acute effect of PA on attention in a school setting is limited, due to differences in study design, and different study samples (7, 13). In addition, as mentioned above, there is a lack of knowledge about the effects of different PA intensities on cognition in children. Therefore, the purpose of this study was to gain insight into acute effects of experimental PA breaks of different intensity on selective attention in 10-11 year old primary school children, in which aerobic fitness was measured as a covariate.

METHODS

PROCEDURE

Between September and December 2011, a convenience sample of seven classes from four primary schools (n=123 children) participated in a randomized cross-over experiment, with a within-design. All experimental breaks took place between 09.30-10.00 after an hour of regular cognitive tasks that were scheduled at that moment. The measurements were conducted with one week intervals. Each participating class was visited five times. At the first visit, children completed the selective attention test three times. The purpose of this first measurement was to acquaint children with the test and the test protocol, and to reduce potential test-learning effects. On the subsequent visits the different experimental breaks (no break, passive break,

moderate intensity PA break, vigorous intensity PA break) were administered, in random order (Figure 1).

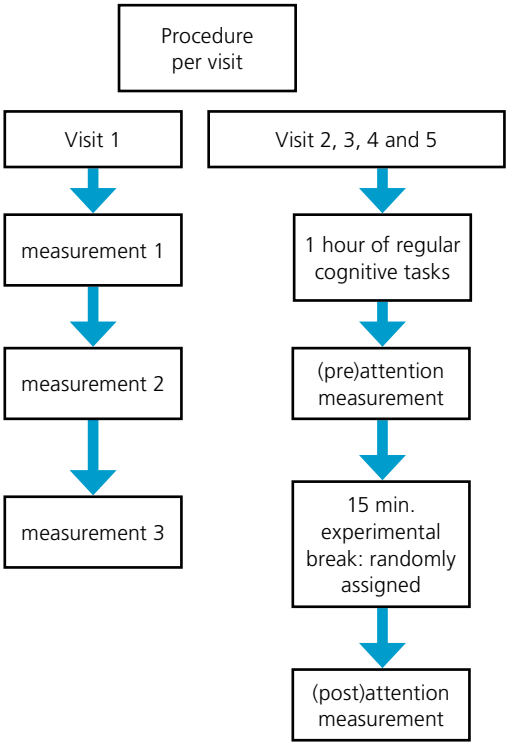

Figure 1: Flow diagram of the procedure

Each experimental break lasted 15 minutes and was supervised by two researchers and the classroom teacher. Selective attention was assessed before and after each experimental break in the classroom.

PARTICIPANTS

The sample included 123 children from the 5th grade, aged 10-11. The participants were recruited from schools that also participated in the PLAYgrounds study (14). Schools were located in the urban area of Amsterdam in neighbourhoods with a relatively large part of the population of immigrant origin and low socioeconomic status. The school register provided demographic information (age and gender). Similar to a previous school-based study (15), parents of the participating children received a passive informed consent form that explained the nature and procedures of the study, allowing them to withdraw their child if they objected to study participation. The Medical Ethics Committee of the VU University Medical Centre approved the study design, protocols and passive consent procedure (NTR2386).

EXPERIMENTAL BREAKS

Each experimental break lasted 15 minutes in total, which equals a morning break in Dutch primary schools. The experimental breaks were administered in a random order.

The first experimental condition was 'no break', in which children continued their cognitive tasks (i.e. mathematics or language exercises) instead of a 'real' break. They were also not allowed to ask the teacher for help or go to the toilet.

The second experimental break was a passive break. The teacher read out aloud a story to the children. Children were neither physically active nor performing difficult cognitive tasks.

The third experimental break was an exercise break consisting of moderate intensity PA and included walking to and from the PE classroom. All exercises were instructed by the researcher and consisted of a combination of jogging, passing of the ball and dribbling with the ball. For example, the children worked in groups of three and had to pass the ball to another child who stood opposite them and then run in the same direction. The next child did the same towards the third child, and so on.

The fourth experimental break was a 15 minutes exercise break consisting of vigorous intensity PA, which included running to and from the PE classroom. All exercises were instructed by the researcher and consisted of a combination of run-

ning, jumping and rope skipping. For example, the children had to perform different rope skipping exercises, exercises with jumping over the rope when it was placed on the floor, and relay races.
The physical activity breaks were performed in the PE classroom. Instructions for each next exercise were given during the previous exercise in order to keep the desired intensity level of PA. The PA breaks were designed in concordance with PE teachers and tested in a pilot setting in order to achieve the predefined PA intensity level. The intensity levels were monitored by ActiTrainer (ActiGraph) accelerometers exclusively during the PA breaks.

MEASUREMENTS

Selective attention

The outcome measure of this study was selective attention. Selective attention was assessed by the 'Sky Search' subtest of the Test of Every day Attention for Children (TEA-Ch) (16). In the Sky Search subtest, children have to find pairs of identical spacecrafts as quickly as possible among distracting pairs of non-identical spacecrafts. In every test 20 pairs were present and finding 15 or more correct pairs was needed to calculate a valid attention score (17). Different configurations of the test were used to present a new pattern of the spacecrafts in each test. At each measurement different versions of the Sky Search were used in random order to reduce a learning effect.
The children were instructed to circle as many identical pairs as they could find, scanning the document, as quickly as possible. In order to measure the individual time, each child received a timer, which each child started him/herself on command and stopped as soon as the search had finished. During the learning day, each researcher timed half of the children in a class, in order to check how well the children were able to time themselves. No significant differences were found between the reported times from researcher and children.
After each test, time to perform the circling task (motor performance) was measured. This motor performance test consisted of the same 20 pairs without the distracting pairs of non-identical spacecrafts.

The final score was calculated as the time needed to identify a pair minus the time for the motor performance test. A lower score indicates better selective attention. The reliability (0.80) and validity (0.90) of the subtest have been reported as moderate to high (16). The correlations with IQ, reading, spelling and arithmetic abilities are 0.14, 0.09, 0.13 and 0.10 respectively, indicating that Sky Search scores are not related with IQ, nor with academic performance (17).

Physical activity

PA intensity was monitored using accelerometers (ActiTrainer, ActiGraph) in order to determine the intensity level during the physically active breaks. The accelerometer was securely attached to the child's right hip by an elastic waist belt. The epoch length was one second and the display was turned off in order to minimize distraction. Data was downloaded using ActiLife 5 software, and average counts per minute were calculated. The following cut-off points were used to determine PA intensity: moderate PA between 2000 and 2999 counts/min and vigorous PA over 3000 counts/min (18). These cut-off points correspond with approximately 3-6 and >6 metabolic equivalent of the respective tasks (METs). A minimum of 12 out of 15 minutes at the intended intensity level was required to include a child in the analysis.

Aerobic fitness

Aerobic fitness was assessed on a separate day in the second week during a scheduled physical education (PE) lesson. Aerobic fitness was assessed using the 20m shuttle-run test (19). The children had to run between two lines, set 20 meters apart, exactly at a prescribed pace, dictated by sound

beeps. The running speed started at 8.0 km/hour and increased every minute by 0.5 km/h (20). The test stopped when a child was unable to follow the pace and missed the line in time for two consecutive times. The score on the 20m shuttle-run was the last full stage the child completed. A higher score on the 20m shuttle-run test indicates better aerobic fitness. The 20m shuttle-run test scores were categorized as bad, poor, fair, good or excellent, based on scores of normative samples that are representative for this age group (21). These scores were dichotomized into high (fair, good or excellent) or low (bad or poor).

STATISTICAL ANALYSIS

The difference between the different experimental breaks was analyzed by a linear multilevel regression analysis to account for the clustered nature of the data. In the multilevel analysis, a four-level structure was applied, with the measurements (n=492) at first level, the children (n=123) at second level, the class (n=7) at third level and the school (n=4) at fourth level. Pre-measurements of attention were included in the model as a covariate. Aerobic fitness (dichotomous) was identified a priori as a potential covariate.

To evaluate the influence of this covariate on the results of the experiment, effect modification was assessed by constructing interaction terms between the different breaks and the covariate aerobic fitness. All multilevel analyses were performed using MLwiN (version 2.21) and a two-tailed significance level of $p<0.05$ (for effect modification: $p<0.10$) was considered statistically significant. Finally, sensitivity analyses were performed excluding children who had scored less than 15 correct pairs (i.e. the minimum score to calculate a valid selective attention score).

RESULTS

The mean age of the children in the study was 10.4 (SD=0.59) years old, with 50% boys. The average score on the shuttle-run test was 6.3 (SD=2.0). Based on the shuttle-run scores, a total of 35 (30.1%) children were classified with a low physical fitness and 77 (62.6%) with a high physical fitness. Table 1 shows the baseline characteristics of the participants.

Table 1 Baseline characteristics of the participants

n=123	
Age in years [mean (sd)]	10.4 (0.59)
Gender [n (%) boys]	62 (50)
Shuttle-run [mean (sd) score]	6.3 (2.0)
Physical fitness [n (%) low]	37 (30.1)

n = number of children, sd = standard deviation.

When either the pre-measurement or the post-measurement of a break was incomplete, the participant was excluded from the analysis for that specific break. A total of 57 data points were missing. From the remaining 435 measurements (from 123 children), 15 measurements were excluded from the analyses due to not reaching the required physical activity intensity level. In total, 97% of the children had reached the required average intensity level of physical activity during the moderate intensity PA break and 91% had reached the intended average intensity level of physical activity during the vigorous intensity PA break. Children who had not reached the intended PA level were excluded from the analyses for that specific break. In the end 420 (84.8%) measurements from 123 children were available for the analyses. Finally, a two-level structure has been used in the analysis, with the measurement at first level and the children at second level. There was no correction required for class or school.

Table 2 (next page) shows the mean selective attention scores pre- and post measurement as well as the difference in selective attention scores between the experimental breaks.

Table 2 Mean attention scores (standard deviation) of selective attention in seconds / target for the pre- and post measurement and differences (B; 95%CI) in attention scores between the experimental breaks. The differences are a comparison of the post-measurements, in which the post-measurements are corrected for the pre-measurements.

	No break (NB)	Passive break (PB)	Moderate intensity PA break (MPAB)	Vigorous intensity PA break (VPAB)
n	112	108	111	89
Pre- measurement mean (sd)	2.7 (0.78)	2.6 (0.82)	2.5 (0.77)	2.5 (0.68)
Post- measurement mean (sd)	2.9 (0.78)	2.5 (0.71)	2.1 (0.58)	2.4 (0.62)
B [95%CI]	[reference]	-0.27 [-0.35;-0.18][a]	-0.59 [-0.70;-0.49][a/b]	-0.29 [-0.39;-0.19][a]

n; number of children in the analysis, sd; standard deviation, PA; physical activity
[a] Significantly different from no break
[b] Significantly different from vigorous and passive break

Test scores were significantly lower (improved selective attention) after the passive break (-0.27, 95% CI:-0.35;-0.18) than after the 'no break'. Test scores after the vigorous intensity PA break were significantly lower than the 'no break' (-0.29, 95% CI:-0.39;-0.19) but not the passive break. After the moderate intensity PA break, the test scores were lowest, and significantly lower than after the 'no break' (-0.59, 95% CI:-0.70;-0.49), the passive break and the vigorous intensity PA break.

When excluding children who had scored less than 15 correct pairs for that specific break, the results were similar, but less pronounced (Table 3). There was no significant effect modification by aerobic fitness.

Table 3 Differences in attention scores between the experimental conditions excluding children who found less than 15 correct pairs. The differences are a comparison of the post-measurements, in which the post-measurements are corrected for the pre-measurements.

	No break (NB)	Passive break (PB)	Moderate intensity PA break (MPAB)	Vigorous intensity PA break (VPAB)
n=316 measurements; 108 cases	No break (NB)	Passive break (PB)	Moderate intensity PA break (MPAB)	Vigorous intensity PA break (VPAB)
B [95% CI]	[reference]	-0.22 [-0.29;-0.15][a]	-0.43 [-0.50;-0.35][a/b]	-0.21 [-0.29;-0.14][a]

[a] Significantly different from no break
[b] Significantly different from vigorous and passive break

DISCUSSION

A significant beneficial effect of both a passive break as well as physical activity breaks on selective attention was found with the strongest effect after a moderate intensity PA break. The larger effect of the moderate intensity PA break is in line with the inverted-U-hypothesis (22). This hypothesis states that cognitive performance is optimally enhanced at a moderate level of arousal (23). The optimal level of arousal for attention in adults is reached after moderate intensity PA (24). This hypothesis was supported by a meta-analysis, concluding that acute, moderate intensity exercise has a strong beneficial effect on speed of response (25). Arguably, this optimal level is the same in children because attentional control is fully developed by the age of seven (26). A recent review focused on the acute effect of a short PA bout on attention in school-aged children, and concluded that also in children intensity level of PA may influence the effect of PA on attention (13). Overall all the included studies that found an effect of acute PA on attention contained a short bout of moderate intensity PA. In studies with a more strenuous (>65% HRmax) PA bout, no effect of PA on attention was found. The lack of an effect of vigorous intensity PA on attention could be explained by the transient hypofrontality theory (27, 28), which states that a decrease in cognitive performance is caused due to brain activation which is required to perform dynamic movements. A reduction in cerebral blood flow (and thereby oxygen) during the vigorous intensity PA break could explain the smaller effect on selective attention, which equaeled the effect after a passive break. In addition, cognitive performance possibly remains decreased for approximately 20 minutes after vigorous intensity PA, because the brain needs time to return to homeostasis (29).

Two other explanations may give a reason for the significantly improved attention after the moderate intensity PA break. Firstly, the exercises in the moderate intensity PA break were of coordinative character. Budde et al. (30) concluded that coordinative exercises might lead to pre-activation of parts of the brain, which are also responsible for mediating functions like attention. In addition, a recent study from Chang, Tsai, Cheng and Hung (31) revealed that coordinative exercise intervention, regardless of intensity, resulted in better attention. This explanation is further supported by a study on cognitive flexibility, which demonstrated that cortical transcranial magnetic stimulation manipulates subcortical cognitive functions (32).

Secondly, motivation or mood state could have played a role. Participating in enjoyable activities may improve mood (33). Maybe the exercises in the moderate intensity PA break were more enjoyed than the more exhausting exercises during the vigorous intensity PA break. Further research should compare the effect of coordinative versus non-coordinative PA on selective attention, as well as the potential moderating effect of 'enjoyment'.

The improved attention after the passive break is in line with other studies that found that taking a mental break from cognitive tasks can already improve selective attention; breaks during periods of sustained cognitive work may reduce cognitive interference (34) and even brief breaks helped to stay focused on the task (35).

LIMITATIONS

PA intensity during the breaks was monitored by accelerometers and generalized to an average PA level for children of 10 years old. Nevertheless, it might be that the vigorous intensity PA break was not vigorous for the fittest children and the moderate intensity PA break was too vigorous for the least fit children. In contrast to previous studies (36, 37), this study found no significant effect

modification by aerobic fitness. The general cut-off points for PA intensity could have obscured a modifying role of aerobic fitness. For future research it is recommended to tailor the intensity of the experiment to the actual level of aerobic fitness of the participant, based on their individual maximal heart rate and maximal oxygen consumption.

Despite a practice run of the Sky Search test at visit 1 (to acquaint the children with the test), the use of different versions of the Sky Search test for every measurement, and the random order of the different versions, a learning effect could have occurred. Additional analyses of the differences between employed versions of the Sky Search showed a significant difference between outcomes of the different versions. Although the order of versions was randomized, one version had been used mainly in the moderate intensity PA break and the outcome of this version differed significantly from the other versions. This could have led to an overestimation of the effect of the moderate intensity PA break.

The results of this study showed a positive effect from a short break – especially the moderate intensity PA break – on selective attention. However more research is needed to define the optimal dosage of PA breaks. Also, the relevance of the improvement of selective attention on total academic performance is questionable. The improvement in selective attention found in this study equals 0.6 seconds per target. Although selective attention is highly important for academic performance (38) and that selective attention impacts language, literacy, and math skills (39), the actual contribution of the observed improvement in selective attention on academic performance is unknown and needs further research longitudinally.

An important strength of this study is that a robust methodology within a real-life setting (school) was employed. The children were their own controls, the experimental breaks and the respective versions of the selective attention tests were randomly assigned. In addition, the data was analyzed with a linear multilevel analysis to account for the clustered nature of the data. Also, the effect of different PA intensities compared to no break as well as to a 'non-active' break was examined.

CONCLUSION

Selective attention, one of the executive functions of cognitive performance, significantly improved in 10-11 year old children after a 15 minutes (exercise) break, with the largest improvement after a moderate intensity PA break. These findings suggest that schools should consider to implement (PA) breaks during the school day to optimize selective attention levels and support learning.

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CHAPTER 8
GENERAL DISCUSSION

The first part of the thesis describes the development, effectiveness and feasibility of PLAYgrounds, a playground programme for primary school children aimed at improving physical activity levels. The second part of the thesis describes the acute effects of short (physical activity) breaks on selective attention. This general discussion summarizes and discusses the main findings of both parts of this thesis, and compares the results to other studies on this topic. Additionally, methodological issues will be identified and discussed. Finally, implications and directions for future practice and research are proposed.

PART 1. PLAYGROUNDS EVALUATION

PLAYgrounds was developed based on effective measures described in the literature, and in the implementation of the programme, practical considerations were taken into account to increase PA levels during recess. The PLAYgrounds programme was evaluated in a prospective controlled trial, with four intervention schools and four control schools that were matched for playground size and PA levels at baseline. The intervention consisted of different components, i.e.: playground alterations by coloured markings; equipment provision; time-management and hotspot-management; teacher encouragement and a supporting physical education programme.
Purpose of the intervention was twofold: to replace chaotic recess play by structured recess play and thereby create more play space for each child, and to convert the playground into an attractive environment to be physically active. PA levels and the percentage of children who had spent time in moderate-to-vigorous intensity PA were measured every two weeks during a whole school year by accelerometry (1486 files) and by the SOPLAY observation method (72 observations).
Physical fitness was measured with the Eurofit Test in the 9- to 12-year-old children at baseline and at follow-up (10 months).

There were significant differences between the intervention group and the control group in PA levels during the intervention. These differences continued to be significant throughout the entire school year. In addition, the SOPLAY data showed that an average of 77.3% of the children engaged in moderate-to-vigorous physical activity in the intervention group, and 38.7% in the control group. The effect of the intervention was strongest for older girls (11-12 years old). Regarding physical fitness; a significant difference at follow-up (after 10 months) was found between the intervention group and the control group for plate tapping, 10x5m sprint and 20m shuttle-run in favour of the intervention group. The effect was stronger for the least fit children at baseline for 10x5m sprint and 20m shuttle-run. The effect of the intervention on 20m shuttle-run was stronger for girls than for boys.

A process evaluation showed that Adoption (80% of the schools adopted the programme), Implementation (70% of the total programme was implemented by all 4 intervention schools) and Maintenance (67% of the implemented programme was maintained after 18 months) were high. This is most likely due to the PLAYgrounds programme being a complete intervention package that included financial, material, and staff support. The component, which was most difficult to maintain, was teacher encouragement (at 3 out of 4 schools implemented and at 2 out of 4 schools maintained) and in particular, the weekly session that teachers were scheduled to play along with the children.

PLAYgrounds that had combined structural playground changes with playground management in primary schools increased average PA levels during recess over the course of one school year. In addition, PLAYgrounds was effective in increasing some gross motor skills (eye-hand coordination, arm speed, running speed and agility) components

and cardiorespiratory endurance in both genders. Therefore, PLAYgrounds should be used to increase levels of PA during recess. However, it is recommended that a high level of support should be added when introducing PLAYgrounds in schools, because the effects were greater under controlled conditions. When the PLAYgrounds intervention is translated into practice, ownership and coordination should be integrated in the tasks of the school team, and maintenance (such as monthly activity themes and an regularly update of the play equipment done regularly) should be accounted for.

COMPARISON TO OTHER PLAYGROUND STUDIES

Previous comparable studies, using playground markings or equipment provision, were also effective in increasing PA during recess. A systematic review on playground variables (1) concluded that positive associations were found of overall facility provision, unfixed equipment and perceived encouragement with recess physical activity. However, a systematic review from 2013 concluded the intervention effects from playground intervention studies were inconclusive (2). In addition, no studies evaluated the impact of these components when introduced in combination. See Table 1 for an overview of previous studies.

Table 1: Comparison to other effective (playground) programmes. From (2)

Reference	Setting	N	Follow-up	Intervention components
Stratton (2000)	primary schools 5-7 years old	47	4 weeks	Playground markings
Stratton and Mullan (2005)	primary schools 7-11 years old	90	4 weeks	Playground markings
Verstraete et al., (2006)	primary schools 10-11 years old	235	4 months	Providing equipment and activity cards
Ridgers et al., (2007a)	primary schools 5-10 year olds	297	6 weeks	Playground markings and structures
Ridgers et al., (2007b)	primary schools mean age 8 years	470	6 weeks and 6 months	Playground markings and zones, providing equipment
Loucaides et al., (2009)	primary schools 10- to 12- year-old	228	4 weeks	Playground markings and space, providing equipment (jump ropes)
Janssen et al., (2013)	primary schools 6-12 years old	1486	10 months	Playground markings and zones, space, providing equipment, encouragement from teachers, supporting PE program

In addition, in contrast to previous studies, PLAYgrounds was evaluated in a large sample of children and with a long-term follow-up of one school year. Most previous studies had a short term follow-up period of 6 weeks or less (See Table 1, on previous page). Only one study examined the intervention effects up to 12 months and concluded a novelty effect may have been found, since the largest effect was in the first phase (6 months) of the intervention and decreased over time (6-12 months) (3). Our study shows that the PLAYgrounds programme provided a sustained effect for increasing recess PA levels during the entire school year, arguably because of the improved monthly motivation of the children due to changing physical activity themes and PE support.

Another important finding of the PLAYgrounds programme was that the least active children (i.e. older girls) were significantly more physically active during recess and showed a better improvement in physical fitness compared to boys and younger children. PLAYgrounds consisted of different components that appealed to girls in particular, without stigmatizing them as physically inactive children. For example, designated skipping and dance areas were created. In addition, by creating a specific area for soccer, there was a more balanced partitioning of the playground between boys and girls. The stronger effect for older girls is quite promising for structured health promotion, since PA levels decrease across adolescence into adulthood (4) and, in general boys are more active than girls (5).

METHODOLOGICAL CONSIDERATIONS

Study population

PLAYgrounds was evaluated in a specific study population. All schools were located in the urban area of Amsterdam in neighbourhoods with a relatively large part of the population consisting of children of immigrant origin with a low socio-economic status. This was reflected in the percentage of children who were daily physically inactive (60.7%) and overweight (30.7%). Therefore, the generalization of the results of the PLAYgrounds programme could be difficult. It is expected that in other schools, with more active children, the effectiveness of the intervention will be lower.

Measurement methods

The described daily physical inactivity in our study population was assessed by PA questionnaire. It could be that the percentage of daily physically inactive children is even higher, because self-reported questionnaires are known to be vulnerable to recall biases and social desirability (6).

In addition, information on the effect of intervention on total daily PA is not available, due to a large amount of missing data at follow-up. Complete data on PA was collected only during recess, but it could have occurred that children had compensated for this higher level of recess-PA throughout the rest of the day by being less active (7).

PA during recess was measured using accelerometers and the SOPLAY observation method. Both measurement methods have advantages and disadvantages. Accelerometers provide an objective measure, but have been validated mostly for walking and running. SOPLAY, on the other hand, is the most practical method for assessing different kind of activities, but the outcome of SOPLAY depends on the researcher's estimation of the intensity of PA. In this study both measurement methods were combined and both showed a significant difference between the intervention group and the control group in favour of the intervention group, as well as the same seasonal pattern during the school year.

Assignment to the intervention group and the control group

Randomisation is the best method to create comparable groups. However, random assignment of schools to the intervention group and the control group was not possible, due to differences between schools in the organization of recess. Therefore, schools were matched for the number of pupils, playground size (600-1200 m2) and baseline playground use (i.e. the average level of energy expenditure at the playground as determined through the SOPLAY observational protocol). After matching, schools were randomly allocated to either the intervention group or the control group.

Controlled intervention translated into practice

After the intervention period had ended, most elements of the programme were maintained (measurements took place 6 months after ending the intervention). However, the schools continued to receive funding and support. This may have provided an artificially high Maintenance of the PLAYgrounds programme, which was made possible by the partnership between the STWT (i.e. the funder of the intervention) and the ALO (i.e. the institution of higher vocational education providing a student as an intern) and might have been lower if this partnership did not exist.

RECOMMENDATIONS FOR FUTURE RESEARCH

PLAYgrounds showed to be effective in increasing PA levels during recess. In this study no information on the effect of the intervention on total daily PA was available. Although PA levels increased during recess, it is possible that children compensated for this higher level of recess-PA throughout the rest of the day. Therefore, in future research, total daily PA should be measured using accelerometry in combination with a PA diary. The PA diary should compensate for the activities that cannot easily be measured by accelerometry (such as swimming, cycling and climbing).

Since recess in the Netherlands lasts 15 minutes, theoretically it could contribute 25% to the recommended total daily amount of PA. Therefore, the use of playgrounds after school (during leisure time) should also be observed in order to evaluate the effectiveness of PLAYgrounds on playground use after school. In Amsterdam, the Municipal Sport Services is active on playgrounds and in public gardens to stimulate sports in the surrounding neighbourhoods. They could play a role in providing play equipment and encouraging children to be physically active.

PART 2. SHORT BOUTS OF PA AND SELECTIVE ATTENTION EVALUATION

Despite an expanding literature on the relationship between physical activity and long-term cognitive performance and acute effects of physical activity on cognition, previous reviews and the review in this thesis have shown that the evidence for an acute effect PA in the schoolsetting is limited, especially on the executive function attention. In the experiment described in chapter six, we tried to gain insight into acute effects of physical activity on selective attention in primary school children, within a schoolsetting. Therefore, an experimental study was carried out in a convenience sample of seven primary schools in 123 10- to 11-year-old children.

All children engaged in four experimental 'breaks' in random order: after 1 hour of regular cognitive tasks, this was followed by a 15 minutes episode with the following conditions 1) 'no break' (continuing a cognitive task), 2) passive break (listening to a story), 3) moderate intensity physical activity break (jogging, passing, dribbling) and 4) vigorous intensity physical activity break (running, jumping, skipping). Selective attention in the classroom was assessed before and after the 15 minutes break

in each condition. Physical activity intensity during the active experimental conditions was monitored by accelerometers.
After the passive break, the moderate physical activity break and the vigorous physical activity break, attention scores were significantly higher (10%, 23% and 10%, respectively) than after the 'no break' condition (7% decrease).
Selective attention, one of the executive functions of cognitive performance, significantly improved in 10- 11-year-old children after a 15 minutes (exercise) break, with the largest improvement after a moderate intensity PA break. These findings suggest that schools should consider implementing (PA) breaks during the school day to optimize selective attention levels and support learning.

COMPARISON TO OTHER SIMILAR EXPERIMENTS

A significant beneficial effect of both a passive break as well as physical activity breaks on selective attention was found with the strongest effect after a moderate intensity PA break. The larger effect of the moderate intensity PA break is in line with the inverted-U-hypothesis (8). This hypothesis states that cognitive performance is optimally enhanced at a moderate level of arousal (9). The optimal level of arousal for attention in adults is reached after moderate intensity PA (10). In our review, which was focused on the acute effect of a short PA bout on attention in school-aged children, we concluded that also in children intensity level of PA may influence the effect of PA on attention (11). The lack of an effect of vigorous intensity PA on attention could be explained by the transient hypofrontality theory (12, 13), which states that a decrease in cognitive performance is caused due to brain activation, which is required to perform dynamic movements. A reduction in cerebral blood flow (and thereby oxygen) during the vigorous intensity PA break could explain the smaller effect on selective attention compared to a moderate intensity PA break.

The improved attention after the passive break is in line with other studies that found that taking a mental break from cognitive tasks can already improve selective attention; breaks during periods of sustained cognitive work may reduce cognitive interference (14) and even brief breaks helped to stay focused on the task (15).

An important strength of this study is that a robust methodology within a real-life setting (school) was employed. The children were their own control, the experimental breaks and the respective versions of the selective attention tests were randomly assigned. In addition, the data was analyzed with a linear multilevel analysis to account for the clustered nature of the data. Also, the effect of different PA intensities compared to no break as well as to a 'non-active break' was examined.

METHODOLOGICAL CONSIDERATIONS

Measurement method of physical activity intensity

PA intensity during the breaks was monitored by accelerometers and generalized to an average PA level for children of 10 years old. Nevertheless, it might be that the standard 'one-size-fits-all' vigorous intensity PA break was not vigorous for the fittest children and the moderate intensity PA break was too vigorous for the least fit children. In contrast to previous studies (16, 17), this study found no significant modification effect by aerobic fitness. The general cut-off points for PA intensity could have obscured a modifying role of aerobic fitness.

Learning effect
Despite a practice run of the Sky Search test at visit 1 (to acquaint the children with the test), the use of different versions of the Sky Search test for every measurement, and the random order of the different versions, a learning effect may have occurred. Additional analyses of the differences between employed versions of the Sky Search showed a significant difference between outcomes of the different versions. Although the order of versions was randomized, one version had been used mainly in the moderate intensity PA break and the outcome of this version differed significantly from the other versions. This may have led to an overestimation of the effect of the moderate intensity PA break.

Measurement method of selective attention
In addition, the Sky Search test was designed as a diagnostic instrument in order to measure attention disorders. It contains 9 subtests. All tests have to be completed in an individual testing environment. In our study, children completed the Sky Search (one of the subtests) in their own classroom, which may have resulted in more distraction.

RECOMMENDATIONS FOR FUTURE RESEARCH
The general cut-off points for PA intensity level, measured with accelerometers, could have obscured a clear role of aerobic fitness. For future research it is recommended to tailor the intensity of the experiment to the actual level of aerobic fitness of the participant, based on their individual maximum heart rate and/or maximum oxygen consumption.
The results of this study show a positive effect from a short break – especially the moderate intensity PA break – on selective attention. However more research is needed to define the optimal dosage of PA breaks. Also, the relevance of the improvement of selective attention on total academic performance is questionable. The improvement in selective attention found in this study equals 0.6 seconds per target. Although selective attention is highly important for academic performance (18) and considering that selective attention impacts language, literacy, and math skills (19), the actual contribution of the observed improvement in selective attention on academic performance remains unknown and needs further research longitudinally.

POLICY IMPLICATIONS
Because all children, regardless of their socioeconomic or cultural background, go to school, school offers the opportunity to reach all children for the promotion of regular daily PA. This fact has resulted in a large number of uncoordinated and isolated projects being offered to schools.
In practice, it has been noticed that classroom teachers, as well as heads of departments, delegate the coordination of such projects to the physical education (PE) teacher. On the one hand, we agree that the PE teacher should have an important role in encouraging children to be physically active and in screening children with health problems. On the other hand, the PE teacher teaches PE continuously through the day, which leaves practically no time to fulfil such a role. For example, during recess the PE teacher has no break and therefore is not able to be physically present at the playground during recess. In addition, the perceived primary priority is for schools to improve cognitive skills, which leads to a low appreciation of the importance of PE and PA.

In order to promote regular daily PA through schools, a programme aimed at increasing PA levels should be integrated in the school system. The process evaluation showed that continuous funding and teacher support seem to be the most important factors for adoption and maintenance of the programme. In addition, the role of the

classroom teacher is highly important; in particular because the PE teacher is not present at the playground during recess. Therefore, teachers need to be inspired to engage fully with the development progress of PA programmes in order to feel the necessity of encouraging PA in children at school. We think the results of the short PA break experiment underline the importance of PA for cognitive development and should inspire classroom teachers to implement regular short PA breaks during the school day.

In addition, policy makers should stress the importance of physical activity during the school day. There should be more coordination on helping schools choosing and implementing effective PA programmes. PLAYgrounds has been recognized as an effective intervention in increasing PA during recess by the Dutch governmental initiative: "Loket Gezond Leven" and has been included in the national database. This database contains information on existing interventions in the Netherlands. These interventions are recognized and evaluated regarding quality, feasibility and effectiveness. This recognition procedure is a cooperation of RIVM Centre of Healthy Living (CGL), the Dutch Youth Institute (NJi), the Dutch Centre of Youth Health (NCJ), the Dutch Institute for Sport and Physical Activity (NISB) and the social sector (MOVISIE). Since the PLAYgrounds programme is included in this national database, the manual of the programme is available for schools or other end-users. Although this database is a helpful tool in choosing effective interventions, schools are not capable enough to implement such interventions, due to a lack of time and priority. The government should reconsider the structure of the school day in which now only one morning recess is available for PA.

PRACTICAL IMPLICATIONS

When schools would like support with the implementation and maintenance of PLAYgrounds, the Academy for Physical Education (ALO) is able to offer support. Schools are informed about the content of the programme and will be helped with the preparation and with solving the problems that occur during implementation or maintenance. In addition, all Health Coaches from the Jump-in programme (i.e. a cooperation between the Social Service and the Health Service of Amsterdam) have been trained in February and March 2014 in order to assist schools when implementing PLAYgrounds. Jump-in is responsible for the health of children from 60 schools in Amsterdam and promotes physical activity and healthy eating. On the long-term, about 9000 children will be offered the PLAYgrounds programme at the playground during recess, because of the cooperation between Jump-in and PLAYgrounds. In Rotterdam, the PLAYgrounds training started in September 2014.
Also, our students (who will become PE teachers) will be prepared for the role they can play in encouraging children to be physically active.

In conclusion, PLAYgrounds is an effective intervention that can be implemented at every primary school, without expensive measures. The programme combines PE and PA in children, but could also increase attention during class. It is likely that it can offer a solid base for further interventions, because the habitual PA of children is encouraged every day during recess. This is especially important for the less active children and those with decreased gross motor skills, who increase their motor skills and joy in PA by being physically active.

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SUMMARY

In this thesis, the development, effectiveness, evaluation, and implementation of the PLAYgrounds programme is described. This programme targets the school's playground with the aim to encourage children to be physically active during recess. In addition, a review on the acute effects of bouts of physical activity on the attention in the classroom in children has been carried out. Subsequently, an experiment was carried out, wherein the effect of various short-term breaks on selective attention was measured. In this summary, the main results of the thesis are described.

In the Netherlands, the number of overweight children has increased in recent years. Inactivity is one of the main causes, and different studies have shown that only a small proportion of children meet the physical activity guidelines. Therefore it is necessary to encourage children to be physically active. Since all children go to school five days a week, schools offers the opportunity to reach all children for the promotion of regular daily physical activity. The playground can be a motivating environment to be physically active, but due to a hierarchy based on age and gender, the intensity level of physical activity at the playground has shown to be low.

A different organization of the playground can ensure that all children are physically active. Therefore, the PLAYgrounds programme was developed. The development is described in chapter two. In this playground programme, intervention strategies have been included, which have been found to be effective in several studies. The effectuation of these strategies is based on practical experience. The programme also had to be structurally embedded in the school structure and had to be financially feasible. In short, PLAYgrounds consists of a framework of five components: 1) an alteration of the playground by coloured markings, by which specific areas for different activities are created; 2) a recess schedule, by which the number of children on the playground at the same time is reduced; 3) the provision of play equipment, by which active usage of the playground is encouraged; 4) teachers who encourage children at the playground; 5) supportive physical education classes, in which ideas for games which can be played in the playground are presented, the skills of children are practiced and from where a monthly theme is initiated. The combination of these measures is aimed at creating more play space per child, and to encourage active usage of the playground.

In chapter three and four the effectiveness of PLAYgrounds is described. Four intervention/schools and four control schools were measured during a full school year. The intensity of physical activity was measured every two weeks with accelerometers, and every month through the SOPLAY observation protocol. In addition, the physical fitness of the children was measured at the beginning and at the end of the school year. To evaluate implementation and maintenance of the programme the RE-AIM model for process evaluations was used, which is described in chapter five.

The results, described in chapter three, showed a significant difference in intensity of physical activity between the intervention/schools and the control schools. In control schools, the percentage of children being moderate to vigorous physically active remained around 40%. In the intervention schools the percentage of active children increased from 39.6 % to 77.3%. This difference was consistent throughout the school year (regardless of season or novelty effect). Also, the results showed that the effect for girls was 1.4 times stronger than for boys, and the effect for children of 10-12 years was 1.3 times larger than for children 6-9 years old.

The measurements for physical fitness (chapter four) showed that the children in the intervention schools had a significantly better score on the eye-hand coordination test, the 10x5 m sprint and 20m shuttle-run, whereby the effect of the intervention on the 20m shuttle-run test was stronger for girls than for boys.

The process evaluation, described in chapter five, shows that schools could implement and maintain the PLAYgrounds programme at a reasonable level. This was likely due to the programme consisting of a total intervention package, including financial and material support and a supportive coordinator. The PLAYgrounds programme now also has been included in the Jump-in programme of the "Amsterdamse Aanpak Gezond Gewicht", in which being physically active at the playground is a priority. Coordinators of Jump-in support the schools in implementing PLAYgrounds. From January 2015 PLAYgrounds will also be introduced within the "LekkerFit!" programme of the municipality of Rotterdam.

In chapter five is furthermore described that the group of teachers play an important role in implementing and maintaining the programme. Yet an active role for the class teacher is challenging to maintain and teachers' participation was an element that was not implemented or maintained in all schools. Even if teachers understood the importance of physical activity during recess, they often could not fulfil an active role in the playground. Schools are – in their own words – primarily responsible for the cognitive development of the children, and therefore, in the second part of this thesis an attempt was made to gather information about the relationship between physical activity and cognition.

The literature shows a positive correlation between physical activity and cognition, but knowledge about the possible effect of a short-term physical activity bout on concentration in the classroom is still very thin, as described in chapter six. This conclusion had to be drawn primarily due to differences in study design, population, the physical activity bout and the measurement method of attention across the various studies.

The follow-up experiment described in chapter seven – in which the effect of different short physical activity bouts (as possible in a regular school break) – showed a positive effect from physical activity on selective attention. The largest effect was found after a moderate-intensity physical activity bout, which was similar to the level of physical activity in the PLAYgrounds programme. The results of this experiment can help teachers to underpin the importance of promoting physical activity at school. A suggestion would be to include multiple active breaks per day. A good playground programme, such as PLAYgrounds, can provide the necessary structure to implement this.

In conclusion, PLAYgrounds has been shown to be an effective, simple and inexpensive intervention, encouraging children to be physically active during recess. In the programme physical activity on the playground and physical education are combined, which may also have a positive effect on the attention in the classroom. It is quite possible that PLAYgrounds also provides a solid basis for other interventions, while children are encouraged daily to be physically active during recess. This is especially important for children who are less active during recess and for those with less motor skills, since improvement of motor skills and joy for physical activity may further facilitate a physically active lifestyle; now and in the future.

SAMENVATTING

In dit proefschrift is de ontwikkeling, uitvoering, effectiviteit en evaluatie van het schoolpleinprogramma PLAYgrounds beschreven. PLAYgrounds heeft als doel om kinderen te stimuleren om te bewegen tijdens de pauze op het schoolplein. Daarnaast is een review gedaan naar het effect van een kortdurende lichamelijke activiteit op de concentratie in de klas bij kinderen. Vervolgens is een experiment gedaan, waarbij het effect van verschillende kortdurende pauzes op selectieve aandacht is gemeten. In deze samenvatting worden de belangrijkste resultaten van het proefschrift beschreven.

In Nederland is het aantal kinderen met overgewicht de laatste jaren flink gestegen. Inactiviteit is een van de belangrijkste oorzaken en uit verschillende onderzoeken blijkt dat slechts een klein deel van de kinderen voldoet aan de beweegnormen. Daarom is het noodzakelijk om kinderen te stimuleren lichamelijk actief te zijn. Aangezien alle kinderen vijf dagen per week naar school gaan, is dat de plek om kinderen te enthousiasmeren voor bewegen. Het schoolplein kan een uitdagende omgeving zijn om te bewegen, maar door een hiërarchie gebaseerd op leeftijd en sekse, blijkt de intensiteit van bewegen op het schoolplein laag te zijn.

Een andere organisatie van bewegen op het schoolplein kan ervoor zorgen dat alle kinderen (meer) bewegen. Daarom is het schoolpleinprogramma PLAYgrounds ontwikkeld. De ontwikkeling wordt beschreven in hoofdstuk twee. In dit schoolpleinprogramma zijn maatregelen opgenomen, waarvan uit de literatuur bekend is dat ze effectief zijn. De uitvoering van deze maatregelen is vormgegeven aan de hand van succesvolle praktijkervaringen. Het programma moest ook structureel ingebed kunnen worden in de schoolstructuur en financieel haalbaar zijn. Kortweg bestaat PLAYgrounds uit een raamwerk met 5 maatregelen: 1) een fysieke aanpassing (middels kleuren) van het schoolplein, waardoor de beschikbare ruimte beter verdeeld wordt onder de kinderen en de gespeelde spellen een afgebakende ruimte hebben; 2) een buitenspeelrooster, waardoor het aantal kinderen dat tegelijk op het schoolplein is, wordt verminderd; 3) het aanbieden van spelmateriaal, waardoor kinderen gestimuleerd worden om een variëteit aan spellen te spelen; 4) aanmoediging door de groepsdocenten bij het buitenspelen, waardoor de kinderen extra gestimuleerd worden om te bewegen; 5) een koppeling met de gymles, waar kinderen ideeën meekrijgen voor spellen die ze kunnen spelen op het schoolplein, hun vaardigheden kunnen oefenen en waarvandaan een maandelijks thema wordt geïnitieerd. De combinatie van deze maatregelen is erop gericht om meer ruimte per kind te creëren en om een actief gebruik van het schoolplein te stimuleren.

Voor de effectmeting van PLAYgrounds, beschreven in hoofdstuk drie en vier, zijn vier interventie- en vier controlescholen gedurende een schooljaar gemeten. De intensiteit van bewegen is iedere twee weken gemeten met beweegmeters en iedere maand met behulp van de SOPLAY observatiemethode. Daarnaast is de lichamelijke fitheid van de kinderen aan het begin van het schooljaar en aan het eind van het schooljaar gemeten. Om het programma te evalueren op onder andere implementatie en onderhoud is gebruik gemaakt van het RE-AIM model voor procesevaluaties, beschreven in hoofdstuk vijf.

Uit de resultaten, beschreven in hoofdstuk drie, bleek dat er een significant verschil in intensiteit van bewegen was tussen interventie- en controlescholen, waarbij het percentage kinderen dat matig tot intensief bewoog op de controlescholen rond de 40% bleef en op de interventiescholen van 39,6% naar 77,3% steeg. Dit verschil was con-

sistent gedurende het schooljaar (onafhankelijk van seizoens- of nieuwigheidseffect). Daarnaast bleek dat het effect voor meisjes 1,4 keer zo groot was als voor jongens en het effect voor 10-12 jarige kinderen 1,3 keer zo groot was als voor 6-9 jarige kinderen.

Uit de metingen voor lichamelijke fitheid (hoofdstuk vier) bleek dat de kinderen van de interventiescholen significant beter scoorden op de oog-handcoordinatietest, de 10x5 m sprint en de 20m shuttle-run, waarbij het effect van interventie op de 20m shuttle-run test sterker was voor meisjes dan voor jongens.

Uit de procesevaluatie, beschreven in hoofdstuk vijf, bleek dat scholen het PLAYgrounds programma goed konden implementeren en onderhouden, omdat het programma een compleet interventiepakket is, inclusief financiële en materiële support en een ondersteunende coördinator. Het PLAYgrounds programma is inmiddels ook opgenomen binnen het Jump-in programma van de 'Amsterdamse Aanpak Gezond Gewicht', waarin buitenspelen op het schoolplein een speerpunt is. Een coördinator van Jump-in ondersteunt de scholen bij het implementeren van PLAYgrounds. Vanaf januari 2015 zal PLAYgrounds ook geïntroduceerd worden binnen het 'LekkerFit!' programma van de gemeente Rotterdam.

In hoofdstuk vijf staat verder ook beschreven dat de groepsdocenten een belangrijke rol spelen in het implementeren en onderhouden van het programma. Toch was een actieve rol voor de groepsdocent lastig vol te houden en was docentenparticipatie een element wat niet op alle scholen geïmplementeerd was of behouden bleef. Ook als docenten het belang van bewegen onderschreven, konden ze vaak geen vorm geven aan een actieve rol op het schoolplein. Omdat de opvatting heerst dat scholen in de eerste plaats verantwoordelijk zijn voor de cognitieve ontwikkeling van de kinderen, is in het tweede deel van dit proefschrift getracht meer informatie te verzamelen over de relatie tussen bewegen en cognitie. Uit de literatuur blijkt namelijk een positieve relatie tussen bewegen en cognitie, maar kennis over een mogelijk effect van een kortdurende beweegactiviteit op concentratie in de klas is nog erg dun, zoals beschreven in hoofdstuk zes. Dit lijkt met name te wijten aan verschillen in studie opzet, populatie, invulling van de beweegactiviteit en de meetmethode van attentie tussen de verschillende studies.

Uit het vervolgexperiment dat is beschreven in hoofdstuk zeven – waarbij het effect van verschillende kortdurende activiteiten (zoals mogelijk in een reguliere schoolpauze) is bekeken – bleek dat pauze ingevuld met lichamelijk activiteit een verbetering van de selectieve aandacht tot gevolg had. Het effect na een pauze met matig intensieve activiteit was het grootst en dit was gelijk aan de mate van activiteit die middels het PLAYgrounds programma wordt aangeboden. De resultaten van dit experiment kunnen docenten helpen met het onderbouwen van het belang van bewegen voor kinderen. Een mooie uitwerking hiervan zou het implementeren van meerdere actieve pauzes per dag zijn. Een goed schoolpleinprogramma, zoals PLAYgrounds, kan daarbij de benodigde structuur bieden.

Concluderend kan gesteld worden dat PLAYgrounds een effectieve, simpele en goedkope interventie is om tijdens de pauze op school kinderen te stimuleren om te bewegen. In het programma worden lichamelijke activiteit op het schoolplein en de gymles met elkaar gekoppeld, wat ook een positieve invloed op de concentratie in de klas kan hebben. Het is goed mogelijk dat PLAYgrounds een solide basis biedt voor andere interventies,

omdat kinderen dagelijks gestimuleerd worden om actief te zijn tijdens de pauze. Dit is extra belangrijk voor kinderen die weinig actief zijn tijdens de pauze en voor minder motorisch begaafde kinderen, die hun motorische vaardigheden en plezier in bewegen verbeteren door meer te bewegen.

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ABOUT THE AUTHOR

Mirka Janssen was born on the 31st of March, 1982 in Amsterdam. After graduating from secondary school from the Bredero College in Amsterdam in 2000, she started her study for PE teacher at the Academy for Physical Education in Amsterdam. After two years of studying, she also started her study Human Movement Sciences at the VU University in Amsterdam. In her fourth year at the Academy for Physical Education, she travelled to New Zealand for a research internship on drafting in triathlon swimming at the Dunedin University. In 2005 she completed her Bachelor at the Academy for Physicial Education and she started working at the ROC Sport & Bewegen in Alphen aan den Rijn, Gouda and Zoetermeer as a teacher in anatomy, physiology and gymnastics.

In 2008 she completed her Master in Human Movement Sciences and started working at the Academy for Physical Education as a teacher in biomechanics and as a member of the research group under supervision of dr. Huub Toussaint. In 2009 she had her first publication (drafting study). She then started as a PhD-student on the PLAYgrounds project in cooperation with the EMGO Institute, under supervision of prof. dr. Willem van Mechelen, dr. Evert Verhagen and dr. Huub Toussaint. In 2010 she and dr. Huub Toussaint developed an educational curriculum for research at the Academy for Physical Education. Since 2010 she teaches research subjects and advises students in research projects at the Academy for Physical Education. In 2013 she completed her Master in Epidemiology at the VU University in Amsterdam.

She lives together with Iwan de Koker and together they have two sons (2 and 0).

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