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van den Berg, V.

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Summary



Schools have an important task to support children in their cognitive-intellectual and social-emotional development, preparing them for their future (school) career. Language and mathematics/arithmetic receive particular attention in school as they are considered important building blocks for the development of other knowledge and skills. Therefore, much of school's curriculum time is spent on these subjects, which subsequently limit the time for other activities during the school day, such as physical activity (PA). However, PA may provide short- and long-term improvements in children's cognitive and academic performance, which can be of interest for school practice.

Although the benefits of PA for children's physical and mental health are widely described in the literature, research on the effects of PA for cognitive performance is upcoming. Many questions remain to be answered. For example, it is unclear what frequency, duration and type of PA may benefit children's cognitive performance. Gaining more insight in the effects of PA on cognitive performance is important to be able to give explicit advice to schools on the implementation of additional PA in school.

Structural implementation of school-based PA programs in daily school practice is challenging. The current focus on performance in language and mathematics/arithmetic subjects and the associated lack of time appears a major barrier for teachers hindering implementation. Moreover, most evaluated PA programs are developed by researchers, and little is known about the needs, interests and preferences of primary school principals, teachers and children when it comes to additional PA in school. More insight in their perspectives is needed to be able to develop PA programs that are feasible and sustainable in daily school practice.

Therefore, the aims of this thesis are 1) to examine the effects of acute and repeated exercise bouts on children's cognitive performance; and 2) to gain insight in the perspectives of primary school principals, teachers and 10 to 13 years old children with regard to additional PA in school.

Part I Acute effects of exercise on cognitive performance

The first part of this thesis is dedicated to the assessment of the acute effects of single exercise bouts on cognitive performance, measured immediately after exercise. In particular, characteristics of effective exercise bouts in terms of exercise *type* and *duration* are identified.

The randomized controlled crossover study described in **chapter 2** examines the acute effects of three different types of 12-minute classroom-based exercise bouts on selective attention and information processing speed in 10 to 13 years old children. One hundred and ninety five children from eight classes

participated in a 12-minute exercise session, either consisting of aerobic, coordinative or strength exercises, and a 12-minute sedentary control session, thereby acting as their own controls. The exercise and control condition were scheduled one week apart and the order of sessions was counterbalanced across classes. Children performed two paper-and-pencil cognitive tasks before as well as immediately after both the exercise and control condition, measuring information processing speed and selective attention. None of the three 12-minute exercise bout types, i.e. aerobic, coordinative or strength, resulted in cognitive improvements, and there were no differential effects of exercise type. The exercise bouts did not deteriorate children's cognitive performance.

The randomized controlled crossover study described in **chapter 3** examines the acute effects of exercise bouts with different duration on selective attention and working memory in 11 to 14 years old children. One hundred and nineteen children participated in an exercise bout of either 10-, 20-, or 30-minutes, and a sedentary control session of similar duration, thereby acting as their own controls. The order of exercise and control condition was counterbalanced and sessions were scheduled one week apart. Two computerized cognitive tasks that measured children's selective attention and working memory performance were administered before and immediately after the exercise and control conditions. There were no acute effects of exercise and no differential effects of exercise duration, i.e. 10, 20, or 30 minutes, on children's cognitive performance. Single exercise bouts of different duration did not deteriorate children's cognitive performance.

Part II Physical activity in school practice: perspectives of school professionals and children

The second part of this thesis focusses on the perspectives of primary school professionals and children in grades 5 and 6. In particular, their motivations, needs, preferences and ideas about (feasible) additional PA in school are explored.

The qualitative study described in **chapter 4** explores the perspectives of school principals and teachers with regard to additional PA in school. Twenty-six school professionals (11 principals and 15 teachers working in the highest two grades of primary school) participated in individual, semi-structured interviews. Principals and teachers expressed their willingness to implement additional PA if it can benefit children's learning. Time constraints appeared a major barrier to structurally implement additional PA in school, and strongly influenced principals and teachers perceptions of feasible PA programs. They indicated that additional PA in school needs to be short (1 to 5, up to maximum 10 minutes), executed in the classroom and provided in 'ready-to-use' materials (i.e. requiring no or little preparation time). Variation in activities, support of the entire school team and a 'PA coordinator'

responsible for the implementation and evaluation were mentioned as important factors for the success of additional PA in school.

The qualitative study reported in **chapter 5** aims to provide insight in 10 to 13 years old primary schoolchildren's perspectives on how to increase PA in school. Thirty-two girls and twenty boys participated in nine semi-structured focus groups. Children were generally enthusiastic about additional PA in school, reported physical, emotional and cognitive benefits and emphasized the need to alternate time working on school tasks with time being physically active. Children had numerous ideas to increase PA in school, including allocating more time for PA in the existing curriculum (e.g. physical education, recess, occasional activities such as field trips or sports days), improving the content of physical education lessons, implementing short PA breaks and physically active academic lessons, and adapting the school playground. According to the children variation and being given a voice in their PA participation are important prerequisites for enjoyable and sustainable PA in school. Moreover, children indicated that it is important to take individual preferences of children into account and make efforts to accommodate all of them. Lastly, children indicated that the teacher has an important role in additional PA in school. Children also suggested to install a 'child PA committee' responsible for the organization and implementation of additional PA in school.

Part III Daily exercise breaks and cognitive performance

Based on the outcomes of the first and second part of this thesis, an exercise breaks program that closely meets the earlier identified needs of school practice was composed. The 9-week program consisted of a daily 10-minute 'Just Dance' exercise break in the classroom.

The cluster randomized controlled trial described in **chapter 6** examines the effects of the exercise breaks program on 9 to 12 years old children's selective attention, inhibition and memory performance, as well as their aerobic fitness and PA levels. Five hundred and twelve children from 21 classes of eight primary schools participated. Half of the classes were assigned to the exercise breaks program and the other half followed a control program. Before and after the 9-week intervention period, children performed four cognitive tasks in domains of selective attention, inhibition and memory retrieval. In addition, a shuttle run test was performed to assess children's aerobic fitness. A subgroup of 330 children from the intervention as well as control classes wore an accelerometer for one week during the intervention period. The exercise breaks program did not result in significant improvements, nor in deteriorations in children's cognitive performance and aerobic fitness. Children in the exercise breaks program group spent on average three additional minutes of moderate-to-vigorous PA per day during school hours compared to the children in the control group.

Implications of the results

In chapter 7 the findings and methodological challenges are critically discussed, and advice to school practice is given based on the results of this thesis.

The results of this thesis show that the tested exercise bouts do not result in cognitive benefits for children in the upper two grades of primary school. It could be that PA has no cognitive benefits among healthy primary school children. However, reasons for finding no effects on cognitive performance could also be due to inadequate intensity, type and duration of the exercise bouts, inadequate measurement instruments or timing of cognitive measurements. Moreover, it could be that PA only provides relevant beneficial cognitive effects after longer time periods. In future studies, researchers should pay attention to multiple school-relevant outcome measures, the feasibility of research-based PA programs in school and the involvement of school professionals and children in research.

There is still insufficient evidence to provide schools with specific advice about the usefulness of PA to improve children's cognitive performance. However, it can be concluded that spending additional time on PA does not result in adverse effects on children's cognitive performance. Given the multiple health benefits of PA and the child- and teacher perceived benefits for children's attention, mood and school motivation, principals and teachers are encouraged to implement PA as part of the school day. In this process, it is important to make additional PA a shared project of teachers and children. In order to increase the chances of successful and sustainable implementation of additional PA, schools could choose feasible and suitable PA opportunities, installing a PA committee and, if possible, increasing involvement of the physical education teacher.

Conclusion

The studies in this thesis found that acute exercise bouts of different types and durations did not improve, nor deteriorate children's cognitive performance. Likewise, 9-weeks of daily short 'Just Dance' exercise breaks in the classroom did not improve, nor deteriorate children's cognitive performance. Principals, teachers and children were generally enthusiastic about additional PA in school, recognized the need for PA and reported multiple benefits, including perceived cognitive improvements. Future research is needed for a decisive answer regarding the effectiveness of PA for cognitive performance, and if so, in what form.