Journal of Science and Medicine in Sport xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Journal of Science and Medicine in Sport

journal homepage: www.elsevier.com/locate/jsams

Original research

Effects of one versus two bouts of moderate intensity physical activity on selective attention during a school morning in Dutch primary schoolchildren: A randomized controlled trial

Teatske M. Altenburg*, Mai J.M. Chinapaw, Amika S. Singh

Department of Public and Occupational Health EMGO Institute for Health and Care Research, VU University Medical Center, The Netherlands

ARTICLE INFO

Article history:
Received 20 November 2014
Received in revised form 16 October 2015
Accepted 6 December 2015
Available online xxx

Keywords:
Cognition
Child
Adolescent
School
Exercise
Physical activity

ABSTRACT

Objectives: Evidence suggests that physical activity is positively related to several aspects of cognitive functioning in children, among which is selective attention. To date, no information is available on the optimal frequency of physical activity on cognitive functioning in children. The current study examined the acute effects of one and two bouts of moderate-intensity physical activity on children's selective attention.
Design: Randomized controlled trial (ISRCTN97975679).
Methods: Thirty boys and twenty-six girls, aged 10–13 years, were randomly assigned to three conditions: (A) sitting all morning working on simulated school tasks; (B) one 20-min physical activity bout after 90 min; and (C) two 20-min physical activity bouts, i.e. at the start and after 90 min. Selective attention was assessed at five time points during the morning (i.e. at baseline and after 20, 110, 130 and 220 min), using the 'Sky Search' subtest of the 'Test of Selective Attention in Children'. We used GEE analysis to examine differences in Sky Search scores between the three experimental conditions, adjusting for school, baseline scores, self-reported screen time and time spent in sports.
Results: Children who performed two 20-min bouts of moderate-intensity physical activity had significantly better Sky Search scores compared to children who performed one physical activity bout or remained seated the whole morning ($B = -0.26$; 95% CI = [−0.52; −0.00]).
Conclusions: Our findings support the importance of repeated physical activity during the school day for beneficial effects on selective attention in children.

1. Introduction

Recently, a systematic review found evidence for a positive longitudinal relationship between physical activity and academic performance in children.[1] To understand the exploratory mechanisms underlying this relationship, it is important to assess which specific cognitive functions (e.g. executive function, information processing, memory) contribute to improved academic performance, and the type, duration, intensity and frequency of physical activity that is required to bring about this effect.

A meta-analysis on the acute effects of physical activity found a small positive effect on cognitive performance in children ($d = 0.17$), with larger effects on tasks categorized as measures of attention, crystallized intelligence and executive function.[2] Executive functions consist of a variety of cognitive processes required to maintain conscious control of thought and action,[3] and can be classified into inhibition control, working memory, set-shifting, cognitive flexibility, contextual memory and planning.[4] A meta-analysis focusing on these different domains of executive functions found a moderate effect of acute physical activity on inhibition/interference control (i.e. suppression of actions and resistance to interference from irrelevant stimuli) in children ($d = 0.57$) and adolescents ($d = 0.52$).[5] No studies on the other domains in children/adolescents were included.[5] Only a few studies included in these meta-analyses were conducted among children and adolescents ($n = 9$ in Chang et al.[2] and $n = 4$ in Verburgh et al.[5]).

The acute physical activity bouts performed in the studies included in Verburgh et al.[5] consisted of a 20-min bout of moderate-intensity aerobic activity[6,7] or a 10-min bout of coordinative activity (e.g. exercises stressing different bilateral coordinative abilities such as to balance, to react, to adjust and to differentiate).[8] Similarly, recent studies demonstrated that an acute bout of 20-min moderate intensity treadmill walking enhanced children's inhibitory control, when compared to seated rest.[9,10] Additionally,

* Corresponding author.
E-mail address: t.altenburg@vumc.nl (T.M. Altenburg).

http://dx.doi.org/10.1016/j.jsams.2015.12.003
1440-2440/

an acute bout of 12-min indoor running at 70–80% of maximal heart rate enhanced children's selective attention (i.e. suppression of actions from irrelevant stimuli and enhancement of actions from relevant stimuli), when compared to 12 min of educational TV viewing.[11] Yet a recent systematic review concluded weak evidence for the effects of acute bouts of physical activity on children's attention.[12] As included studies varied largely in type (e.g. aerobic, coordinative) and duration (10–45 min) of the physical activity bouts, no current evidence exists on the most favourable activity type and duration.[12]

The studies mentioned examined the acute effects of a single bout of physical activity. To date, no information is available on the optimal frequency of physical activity bouts enhancing executive functions in children. In the present study we examined the effects of acute effects of a single and repeated 20-min moderate intensity physical activity bout on selective attention, e.g. the capacity to improve the processing of particular target characteristics regardless of spatial location,[13] during a school morning in children. Moderate intensity physical activity bouts were implemented at the start and halfway a morning. We hypothesized that both one as well as two bouts of moderate-intensity physical activity would enhance children's selective attention, with larger effects for repeated bouts, when compared to sitting the whole morning.

2. Methods

A convenient sample of thirty-three boys and twenty-nine girls, aged 10–13 years, participated in this study. Children were selected via various contacts of the research staff and originated from five schools (from one class per school) in the province of Noord Holland, The Netherlands. Inclusion criteria were (1) aged between 10 and 13 years, (2) apparently healthy and (3) Dutch speaking. Children were requested to refrain from any moderate-to-vigorous physical activity (MVPA) for at least 3 days prior to the experiment. Moreover, we asked children and their parents to avoid active transport and arrive after an overnight fast at school the morning of the experiment. All children received a standardized breakfast, snack and lunch to minimize effects of food intake on cognitive functioning.[14]

This study included three experimental conditions and was performed during a morning in the school setting. Data collection took place from June until November 2013. At each school children were randomly assigned to the following experimental conditions, using a pre-determined computer-generated block randomization list, with blocks of 8 children per group per measurement day, up to a maximum of 20 children per group: (A) no physical activity (i.e. sitting all morning working on simulated school tasks, control group); (B) one 20-min physical activity bout halfway the morning; and (C) two 20-min physical activity bouts, i.e. at the start and halfway the morning. Selective attention was measured at different time points during the morning (see Supplementary Fig. 1). The study was approved by the Medical Ethics Committee of the VU University Medical Center in Amsterdam (2013/093), the Netherlands, and was in accordance with the Declaration of Helsinki.

Children arrived at school around 8 A.M. First, anthropometrics (all groups) and resting heart rate (groups B and C) were assessed. Thereafter, children consumed breakfast. Subsequently, all children completed the cognitive test three times (i.e. pre-testing) to reduce possible learning effects. After completing the pre-testing cognitive tests, children in group A remained seated all morning. Children in group B had an active break of 20 min after 90 min of sitting and remained seated during the rest of the morning. Children in group C started the morning with a 20-min physical activity bout, had an active break after 90 min of sitting and remained seated during the rest of the morning. During the seating hours, children performed simulated school tasks. Selective attention was measured at baseline (T0), after 20 min (T1; i.e. after the first physical activity bout in group C), 110 min (T2; i.e. before the second bout in group C), 130 min (T3; i.e. after the second physical activity bout in group C) and at the end of the morning (T4; i.e. after 220 min). Supervising research staff (i.e. minimal one supervisors per three children) was present during the whole experiment ensuring standardized procedures.

The physical activity bout consisted of a 20 min aerobic workout at moderate intensity, comprising video-based dance activities. In this workout children attempted to mimic the moves that were displayed on a screen, under supervision of the research staff. Workout intensity was determined using the Karvonen formula.[15] According to this formula, target heart rate (HR) was determined via the HR reserve (HRR) by using the formula: target HR = {[%HRR/(maximum HR − resting HR)}. Maximum HR was predicted by the formula: [208 − (0.7 × age)], which closely predicts mean maximal HR in children.[16] Resting HR was obtained after children had been sitting for 10 min. Moderate intensity was defined as 40–60% HRR.[17] To check their HR during the activity bouts, children in group B and C wore a HR monitor (Polar and Suunto). Research staff regularly checked children's heart rate as a guide of actual intensity, and encouraged them to increase their intensity when their heart rate fell below the moderate intensity level.

Selective attention was measured by the 'Sky Search' subtest of the 'Test of Selective Attention in Children' (TEA-Ch).[13] In short, children had to detect 20 pairs of identical spacecrafts, distributed among 108 distractors, as quickly as possible. To account for differences in motor speed, children completed a motor control version of the 'Sky Search' test, in which all distractors were removed. For each part of the test, children were asked to record and register the time they needed to complete the task, using a stopwatch. The research staff made sure time measurement was done correctly and counted the correctly detected pairs of identical spacecrafts. Two different versions of the Sky Search test were randomly assigned to the children at the different time points. For both parts of the Sky Search test, a time-per-target score was calculated (time/targets found). The selective attention score was calculated by subtracting the 'motor control' time-per-target score from the more attention demanding Sky Search time-per-target, thereby obtaining an attention score that is relatively free from motor slowness or clumsiness influences.[13] A lower score on the Sky Search test indicates a better score on attention. Test–retest reliability of the Sky Search subtest of the TEA-Ch over a time period of 5 to 20 days demonstrates high reliability (correlation = 0.90).[13] Thus far, no information is available on test–retest reliability within shorter time periods. We therefore examined test–retest reliability within time frames of 20 and 110 min, respectively, among participants in groups A and B (i.e. children who remained seated during the these time frames).

Body height and weight were measured using a standardized protocol. Body height was measured with a Seca Leicester portable stadiometer with an accuracy of 0.1 cm. Body weight was measured with a calibrated electronic scale (Seca 861) with an accuracy of 0.1 kg. Body height and weight were measured in order to calculate BMI (kg/m^2). Age- and gender-specific BMI values (BMI-z) were calculated using WHO cut-points.[18]

We assessed sports participation (primary and secondary sport; h/week), TV viewing (min/day) and computer use (min/day) using relevant items from the child questionnaire for the ENERGY cross-sectional survey.[19] Intraclass correlation coefficients (ICC) for the questions assessing child reported time spent on sports indicated good-to-excellent test–retest reliability (ICC: 0.68–1.00) and moderate-to-excellent construct validity compared to an interview (ICC: 0.51–1.00). The ICCs for questions assessing children's screen time (i.e. TV time and computer use) indicated good test–retest

Please cite this article in press as: Altenburg TM, et al. Effects of one versus two bouts of moderate intensity physical activity on selective attention during a school morning in Dutch primary schoolchildren: A randomized controlled trial. *J Sci Med Sport* (2015), http://dx.doi.org/10.1016/j.jsams.2015.12.003