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Physically active vs. sedentary academic lessons: A dose response study for elementary student time on task

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ABSTRACT

Background. Physically active academic lessons are an effective intervention to reduce sedentary time and increase student physical activity. They have also been shown to enhance task engagement, as indicated by observations of attention and behavior control, time on task (TOT). However, it is not clear if the improved TOT stems from the physical activity or if it is the result of an enjoyable break from traditional instruction. If it is due to physical activity, what dose of intensity is required for the effect? This study was designed to test these questions.

Methods. Participants were 320 children (7–9 years) recruited from school districts in Central Texas in 2012. They were assigned by classroom ($n = 20$) to one of four conditions: 1) sedentary, standard lesson ($n = 72$); 2) sedentary academic game ($n = 87$); 3) low to moderate intensity PA (LMPA), academic game ($n = 81$); and 4) moderate to vigorous intensity PA (MVPA), academic game ($n = 76$). Measures included PA via accelerometer and TOT.

Results. Mixed-method RMANOVA indicated TOT decreased following the standard lesson ($p < 0.001$), showed no change following the sedentary academic game ($p = 0.68$), and increased following the LMPA ($p < 0.01$) and MVPA ($p < 0.001$) academic games.

Conclusions. While the sedentary, academic game prevented the reduction in TOT observed in the standard lesson, PA resulted in increased TOT. Future research should be designed to examine the potential academic benefits of the change in TOT.

1. Introduction

1.1. Dose response of physically active academic lessons on elementary student time on task

Physical activity is an important aspect of children's health and development. Although children are recommended to obtain at least 60 min of moderate-to-vigorous intensity physical activity each day (CDC, 2008), it is estimated that by 12 years of age, fewer than half of U.S. children are meeting these recommendations (Fakhouri et al., 2014). Concurrently, negative health outcomes historically occurring in the adult population have been diagnosed in children, including type 2 diabetes, elevated blood pressure and low HDL cholesterol. Estimates show as high as 5% of children are diagnosed with metabolic syndrome (DuBose et al., 2006) and only 18.6% of overweight and 15.4% of obese children meet the recommendation for physical activity (Sun et al., 2010). Because the level of physical activity declines from childhood to adolescence (Troiano et al., 2008), it is important to intervene in the elementary years.

Given that children spend up to 30 h at school – with 92% of that time being sedentary (Burns et al., 2015) – it is important to consider interventions to create opportunities for increased physical activity in this context. Typical strategies include increasing the amount of time or the intensity of the activity in P.E. class or recess, and have been met with general effectiveness in increasing overall activity (McKenzie et al., 2001; Sallis et al., 1997; Huberty et al., 2011). However, with increasing prevalence of high stakes standardized testing, PE and recess time has been reduced (Trost et al., 2009). This increases the need to consider interventions that target the regular education classroom. These interventions are particularly attractive as they replace sedentary, classroom behavior with physical activity and are in-line with the idea of physical activity throughout the school day (Carson et al., 2014). However, as teachers often view physical activity interventions as a competing demand during classroom time (Ward et al., 2006), it is unrealistic to expect support from school administrators without demonstrating a clear academic benefit to in-class physical activity. In this vein, programs such as "Take 10!" (Kibbe et al., 2010), "Physical Activity Across the Curriculum" (Donnelly and Lambourne, 2011), and "Energizers" (Mahar et al., 2006) utilize physically active, academic lessons to inject

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10–15 min of MVPA while incorporating academic content. These programs have been shown to be both feasible (Delk et al., 2014) and cost effective (Babey et al., 2014). More importantly, they have been consistently shown to increase physical activity (Stewart et al., 2009; Donnelly et al., 2009; Erwin et al., 2011; Holt et al., 2013) and contribute to factors that are associated with academic performance.

The most studied aspect of academic performance in response to these interventions has been task engagement or time-on-task (TOT). TOT refers to the amount of time students spend attending to school-related tasks (Prater, 1992). It is a direct measure of attention and behavioral control and, thus, student engagement, and it is positively associated with academic performance (Stallings, 1980). Mahar et al. (2006) tested the effects of active lessons on TOT in third and fourth grade children. TOT was measured prior to and following a physically active lesson and a standard, control lesson. Results indicated that TOT increased by 8% immediately after completing the active lesson but no change following the control lesson. A follow-up study (Grieco et al., 2009) found somewhat contradictory effects in that TOT decreased significantly following the sedentary, standard lesson, while there was no change in TOT following active lessons. While both studies demonstrated a benefit – either increasing TOT or preventing a reduction in TOT – it is not clear why these studies differed in the pattern of effect. One possibility is that these reflect ceiling effects due to differences in pretest TOT in each study. Mahar et al. (2006) found pretest TOT scores of approximately 71%. In contrast, Grieco et al. (2009) found pretest scores of approximately 84%. One might expect physically active lessons to enhance TOT in those students experiencing depressed levels of engagement, while maintaining TOT for those already strongly engaged. In addition, neither study reported the intensity of the activity during the lessons. Differences in the lesson content, the person leading the activity, the students, and the environment may all contribute to differences in the dose of physical activity intensity that might impact the resulting TOT. In addition, these physically active academic lessons are designed to be enjoyable (Vazou and Smiley-Oyen, 2014; Vazou et al., 2012), with children often acting out movements from stories or competing as teams to answer academic questions. As a result, physical activity has been confounded by an enjoyable break from traditional lessons. Thus, it may be that an enjoyable – though sedentary – lesson would be just as effective as an active lesson for a change in TOT. This study was designed to address these limitations by having a large group of children complete a traditional, sedentary lesson, or one of three competitive, academic lessons that were completed at sedentary, light or vigorous intensities. Intensity was directly measured through accelerometry, and TOT was directly observed by research staff blinded to condition. Thus, this study is designed to determine if physical activity is required to produce the benefit for TOT and, if so, the dose of activity intensity required.

2. Methods

2.1. Design overview

This study utilized a mixed factorial design, with two levels for the within-subjects factor (pre, post-lesson) and four levels for the between-subjects factor (activity intensity dose). Participants were randomly assigned to condition by classroom ($n = 20$; 5 classes for each condition): (1) traditional sedentary lesson; (2) sedentary game (high interest control), (3) low to moderate-intensity physically active (LMPA) game, and (4) moderate to vigorous intensity physically active (MVPA) game.

2.2. Participants

Participants were a part of an on-going study to compare the impact of active lessons on physical activity conducted in 2012 in CentralTexas. For the larger study, 660 students across experimental and control schools were required to achieve 80% power to detect a significant effect for physical activity. The present study utilized children from the experimental schools. Specifically, 320 children aged 7 to 12 years ($M = 9.5$; 51.2% female) were drawn from twenty 3rd, 4th and 5th grade classrooms within a Central Texas, suburban school district. This age-range reflects the participant demographic in studies designed to examine similar outcomes (Mahar et al., 2006; Donnelly et al., 2009) and represents the age range during which physical activity declines significantly (Fakhouri et al., 2014; Sun et al., 2010; Trost et al., 2002). Participation was limited to those students whose physical abilities allowed them to participate in their physical education class without significant modification, i.e. children who could perform the actions required for the mod-vigorous intensity condition. No data were collected on learning disabilities and, thus, this was not a consideration for inclusion. In line with the procedures as outlined by the Institutional Review Board, parental informed consent was collected for all participants who then provided written assent for participation.

2.3. Physically activity academic lessons

The physically active academic lesson used was "spelling relay." This lesson requires 10–15 min of physical activity and is similar to other active lessons (Stewart et al., 2009; Gibson et al., 2008; Mahar et al., 2006). Students are divided into groups and given a word from their required curriculum. Upon a starting cue, the first child in each group would write a letter, followed by the second child who would add a letter or make a correction. This would be continued throughout the group until the word was completed. Finished words were evaluated and feedback provided for errors. The process would begin again and continued until the 15-min lesson expired. The intensity of the activity was varied to create the four conditions: (1) *Sedentary*, *Non-competitive Traditional Lesson*. Students were seated and instructed to write the given word in "pyramid style." This commonly used classroom activity consisted of students writing the first letter of the word on one line, then two letters on the second line, and so forth until the full word is completed. The order was then reversed, removing a letter at each line. (2) *Sedentary Competitive Game*. Students were seated in a group of four passing a piece of paper around the circle, with each subsequent student adding a letter. The group of students worked in a relay competition with other groups. (3) *Low-Moderate Intensity Physical Activity* (*LMPA*) *Competitive Game.* Students were divided into four groups, with approximately 5 students per group. Students were instructed to walk to and from the board and to sit down between turns. (4) *Moderate-Vigorous Physical Activity* (*MVPA*) *Competitive Game.* Students were divided into six lines, with approximately 3 students per group. Students were instructed to run to and from the board and execute various jumps (e.g., star jumps) as they awaited their next turn. Classrooms were randomly assigned to each of these four conditions. To ensure treatment fidelity, the lead researcher implemented all conditions within each class. Finally, to ensure that the implementation did not impact TOT ratings, a separate group of trained researchers, who were blind to condition, conducted all TOT assessments. Likewise, children were blind to condition until after the pretest questionnaires and observations were complete.

2.4. Time on-task (TOT) observations

2.4.1. Calculation of TOT

Time on-task (TOT) was measured through momentary time sampling (MTS), a type of ecobehavioral assessment. This is based on direct observation of student behavior, in which research staff conducts a series of observational sweeps across the classroom. The order was predetermined in a set direction through the class to reduce the likelihood of missing a child on any sweep. This order was repeated throughout the observation period. During each "sweep" the research staff spends 5 s on each child and notes his/her behavior as either on or off task.