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Acute Classroom Exercise Breaks Improve On-Task Behavior in 4th and 5th Grade Students: A
Dose-Response

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Abstract

This study was the first to directly compare the acute effects of 5, 10, and 20 minutes of classroom exercise breaks on on-task behavior. **Methods:** In this within-subject experiment, 96 4th and 5th grade students, in 5 classroom groups, participated in each of four conditions: 10 minutes of sedentary classroom activity and 5, 10, 20 minutes of classroom exercise breaks led by research staff. On-task behavior was directly and systematically observed from videotapes before and after each condition. The post-test time-on-task scores were compared using a repeated measures mixed ANCOVA, adjusted for age, classroom, and the time-varying pre-test time-on-task. **Results:** Time-on-task was significantly higher in students after 10 minutes of classroom exercise breaks compared to a sedentary attention control (87.6% vs 77.1%, $d=0.45$, $p=.004$). **Conclusions:** Ten minutes of classroom exercise breaks improved on-task behavior in children.

Keywords: physical activity, health promotion, pediatrics

Many factors influence students' performance in school and on standardized academic tests (Best & Miller, 2010; Dollinger & Clark, 2012; Duckworth, Quinn, & Tsukayama, 2012; Rowe, Miller, Ebenstein, & Thompson, 2012). One large influence on academic achievement is student on-task behavior and attention (Frazier, Youngstrom, Glutting, & Watkins, 2007; Rudasill, Gallagher, & White, 2010). Thus to improve academic achievement, many teachers and interventions have aimed to increase on-task behavior or time-on-task (Amato-Zech, Hoff, & Doepke, 2006; Hawkins & Axelrod, 2008; Riley, McKeivitt, Shriver, & Allen, 2011). Emerging evidence suggests that one way to increase on-task behavior is through increasing physical activity opportunities during the school day (Grieco, Jowers, & Bartholomew, 2009; Mahar, et al., 2006; Pellegrini, 1995; Pellegrini & Davis, 1993). Physical activity in children has been shown to improve neuroelectrical activity, (Hillman, Kamijo, & Scudder, 2011) attention and inhibitory control (Drollette, Shishido, Pontifex, & Hillman, 2012) which help students to rule out distractions and focus on the task. When researchers have objectively observed on-task behavior in relation to recess, they found that students are more on-task after recess (Jarrett, et al., 1998; Pellegrini, 1995). Attention and the ability to inhibit distracters, which both contribute to on-task behavior, have both been shown to improve after an acute bout of physical activity in children (Drollette, et al., 2012; Hillman, Buck, Themanson, Pontifex, & Castelli, 2009). Additionally, an observational study found that teachers report better classroom behavior in schools where students have greater amounts of recess (Barros, Silver, & Stein, 2009).

Unfortunately, adding physical activity to the school day can be difficult due to the competing priorities, budget concerns and lack of time reported by teachers and administrators (Center on Education Policy, 2011; Cox, et al., 2011). Classroom exercise breaks, short bouts of

physical activity integrated within the school day, provide a low-budget and feasible way to increase physical activity in students. Components of Take 10!, an example classroom exercise break curricula, have been integrated into numerous interventions, and have had a generally positive effect on educational and health outcomes (Kibbe, et al., 2011).

Few studies, however, have examined the acute effects of these short exercise bouts on on-task behavior in children. Mahar et al. observed on-task behavior before and after a classroom exercise break and found that on-task behavior increased by 8 percent after the exercise (Mahar, et al., 2006). Another study found that exercise breaks can help students maintain on-task behavior (Grieco, et al., 2009). Little is known on the optimal dose of these classroom exercise breaks. Kubesch et al. found positive cognitive effects after 20 minutes of physical education but not after 5 minutes of a classroom exercise break (Kubesch, et al., 2009). To our knowledge, no study has directly compared different durations of classroom exercise breaks on on-task behavior or attention.

Also unknown are the differential effects of classroom exercise breaks between classrooms and individual students. In the two studies to observe on-task behavior after classroom exercise breaks, both found that the effects were different based on student characteristics (Grieco, et al., 2009; Mahar, et al., 2006). In those studies, the effects of classroom exercise were the most beneficial in those with attention difficulties (Mahar, et al., 2006) and with higher body mass index (Grieco, et al., 2009). Other individual differences in responses have not been examined. These variations in response can be lost when results are examined in unstratified groups.

The purposes of this experimental study were to determine the acute effects of classroom exercise breaks on on-task behavior in elementary school students and to examine the differences

in responses between 5, 10 and 20 minutes of exercise. Additionally, the effects were examined by individual classrooms and several individual student factors including gender, intelligence quotient (IQ), fitness, fatness, behavior, school engagement and baseline on-task behavior.

Methods

Participants

A convenience sample of a school and classrooms was selected through agreement of the principal and teachers. Participants ranged from 9 to 12 years of age and were 4th or 5th grade students in one elementary school in South Carolina. All students from eight participating classrooms were invited to participate. Classrooms in the school were grouped on the basis of academic abilities and interests. To efficiently administer the intervention to consenting students, some classes were combined and the intervention was delivered to five classroom groups.

Procedures

This study used a within-subjects experimental design with students exposed to each of four conditions: 10 minutes of seated classroom activity and 5, 10, 20 minutes of classroom exercise breaks. The order of conditions was randomized to each classroom group, with students participating in one condition per week, using a Latin Square design, to counterbalance practice effects (Shadish, Cook, & Campbell, 2002). Time-on-task was measured before and after each condition while the students performed pencil-and-paper tasks. This pre-post design was used to account for daily variation in time-on-task. To familiarize students with the classroom exercise breaks, thus reducing novelty effects, students participated in two days of classroom exercise breaks per week. Time-on-task was only observed on one day a week. All observations were

held on the same time and day of the week for each classroom group. Parent consent and student assent were obtained for all participants.

Treatments

The Brain BITES (Better Ideas Through Exercise) exercise break intervention was led by research staff twice a week for the 4-week study duration. The exercise breaks were designed to maintain moderate-to-vigorous physical activity and to be fun and engaging for the students. Specific exercises were selected to be feasible within a small classroom setting and included marching in place with arm movements, various forms of jumping, and running in place. Exercise sessions were performed to music selected by the students in a brief planning session prior to the intervention and the instructor verbally encouraged as well as physical participated in all sessions. To further encourage participation, the instructor encouraged students to get their heart rates to 150 beats per minute. Students recorded their own self-palpated carotid or radial pulse rates immediately after each session.

Activities were similar across the four exercise conditions; only the duration of activities varied. All intervention conditions were videotaped and coded for physical activity intensity. The three exercise durations were 5, 10, and 20 minutes of classroom exercise breaks. These durations were selected because research has found acute effects in similar outcomes with 10 and 20 minutes of physical activity (Hillman, Pontifex, et al., 2009; Mahar, et al., 2006). Limited evidence has shown that briefer periods of physical activity may not be sufficient to elicit acute improvements in cognitive functions (Kubesch, et al., 2009), however, for feasibility and sustainability, briefer sessions are more likely to be implemented and integrated within busy classroom schedules.

Measures

Baseline measures were administered prior to the intervention. Standardized height and weight were used to calculate Body Mass Index (BMI). Participating students completed the 15m PACER test from the FITNESSGRAM battery as an estimate of aerobic fitness. Students were individually administered the Kaufmann Brief Intelligence Test-Second Version (KBIT-2) as a measure of abbreviated IQ. Additionally, students completed a brief survey on their previous academic grades, physical activity levels (Eaton, et al., 2010), and engagement in school (O'Farrell & Morrison, 2003). Parents completed a brief survey on parent education, race and socioeconomic status. They also completed the Conners' Parent Rating Scales Revised short edition, a 27 item checklist to assess attention-deficit/hyperactivity and problem behavior symptoms.

Physical Activity Intensity. To assess the fidelity of the intervention, videotapes of all four conditions were coded for intensity of physical activity using a modified System for Observing Fitness Instruction Time (SOFIT) as modified by Donnelly (McKenzie, Sallis, & Nader, 1992). Observations were made of individual children at consecutive 10-second intervals during the exercise or sedentary condition, not including cognitive testing. Their average activity level during the 10-second interval was coded using a scale from 1 to 5 where 1 is equal to lying down and 5 is equal to being very active (ex. running in place, jumping). Videos were viewed and coded three times with a different child observed for the same intervals during each viewing. Each participant was observed an average of 16.8 times during the sedentary condition, 7.5 times during the 5-minute exercise break, 12.5 times during the 10-minute break, and 25.5 times during the 20-minute break. To assess reliability, ten percent of the intervals were recoded four months after the initial coding (n=424). Intervals were randomly selected in groups of 10. The percent agreement was 91.0% with a weighted kappa of 0.95.

Time-on-task. To obtain an ecologically valid measure of time-on-task, children were directly observed as consistent with previous studies (Mahar, et al., 2006; Pellegrini, 1995). A systematic time sampling observation system was used. Multiple observation intervals of time-on-task have been used ranging from 10 seconds (Mahar, et al., 2006) to 30 seconds (Pellegrini, 1995) to 1 minute (Bragg, Tucker, Kaye, & Desmond, 2009; Pellegrini & Davis, 1993). As used by Riley et al (Riley, et al., 2011), a 15 second observation interval was selected for this study. To be able to assess time-on-task in all participants within the short testing frame, video cameras, placed in the front of the classroom were used for direct observation. Consented students were observed for time-on-task during the testing procedure. Time-on-task was determined by the direction of the student's gaze, either at the instructor or on the testing materials (Pellegrini, 1995).

Students were observed while completing paper-and-pencil tests before and after each condition. The videos were edited so only the testing procedures, and not the treatment condition, were included and the videos were assigned random identification codes. Both observers were unaware of the time and condition of testing, remaining blinded to the condition. Each video segment was viewed three times. A student was viewed for 15 seconds and the number of off-task interruptions was tallied. Off-task behavior included direction of gaze away from the instructor or testing materials, speaking out of turn, and excessive fidgeting. The observer cycled through all visible students in three viewings of the complete condition from left to right, right to left, and beginning in the center of the classroom. Different students were observed at each 15-second interval between the 3 viewings. If a student was not visible for at least 5 seconds during the 15-second interval (due to obstructed camera view from another

student or the student was in a position where the observer could not see his or her face), the observer proceeded to the next student.

Videos were watched by two observers (an observer blinded to the study aims, and the primary investigator). Both observers viewed the same students at the same time intervals. During the first round of coding, interobserver agreement was 81 percent with a kappa statistic of 0.41. While the agreement was moderate (Landis & Koch, 1977), each interval that differed between coders were examined a third time to reach agreement. For the analysis, if a student was off-task at all during the 15-second interval, that interval was considered to be off-task (regardless of the total count of off-task interruptions). The percentage of intervals coded as on-task for each student during each condition was used as the dependent variable.

Data Analysis

Descriptive statistics were calculated for the total group and each classroom group individually using SAS 9.2. Between-group comparisons were made using ANCOVA or chi-square tests. The intraclass correlation for pre-test time-on-task scores was 0.525. Due to this variation, pre-test time-on-task scores for each condition were included in the model testing the overall effect.

A repeated measures mixed ANCOVA model tested the difference in post-test time-on-task between conditions, adjusted for classroom group and age and with pre-test time-on-task scores included as a time-varying covariate (PROC MIXED). Mixed models using maximum likelihood estimation were used to account for the time-varying covariate of pre-test time-on-task, to utilize all available data, and account for the within-subject correlation with repeated measures. To examine to differences between durations of classroom exercise breaks, linear contrasts compared post-test time-on-task for each exercise condition to the sedentary condition.

To examine the differences between classroom groups and individual student characteristics, these analyses were repeated separately for each classroom group. Interactions between potential effect modifiers were added to the model of the total group including gender, IQ (Friedman, et al., 2006), fitness (Buck, Hillman, & Castelli, 2008; Chomitz, et al., 2009; Hillman, Buck, et al., 2009), BMI (Li, Dai, Jackson, & Zhang, 2008; Taras & Potts-Datema, 2005), attention-deficit/hyperactivity problem behavior symptoms (Gapin & Etnier, 2010; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005), and school engagement. Participants were categorized based on the median split of the potential modifiers. Students were also split into the most on-task and the least on-task students using the mean pre-test time-on-task from each of the four conditions. Mahar et al. previously used a cut-off of less than 50% on-task behavior to classify the least on-task students (Mahar, et al., 2006). In this study, only 6 participants averaged less than 50% on-task behavior, therefore, students who were on-task less than 60% of the time were considered to be the least on-task.

Results

Of the students participating in the study, 10.7% were black, 68.8% were white, and 34% had a parent income less than \$40,000. There were between classroom group differences in age (as expected with multiple grade levels), verbal IQ and physical activity levels as seen in Table 1. One classroom group did not complete the entire research protocol due to technical (camera malfunction), logistical (students obstructing the camera view) and scheduling difficulties that prevented observation of on-task behavior for all four treatments. Additionally, that classroom was the only classroom who participated in the intervention at the end of the school day causing

disruptions that precluded that classroom from being exposed to all of the treatments. Therefore, this classroom was excluded from the analyses.

Seventy-five students in four classroom groups were included in the analyses. The intervention was implemented with high-fidelity and an average intensity (scale from 1 to 5 where 1 is equal to lying down and 5 is equal to being very active) of 4.35 (SD 0.47), 4.37 (SD 0.32), and 4.29 (SD 0.33) for the 5, 10, and 20 minutes classroom exercise break conditions respectively. There was a significant improvement in observed on-task behavior after 10 ($p < .01$, $d = .50$) and a trend toward increased on-task behavior after 20 minutes ($p = .056$, $d = .32$) of exercise compared to the sedentary condition, see Figure 1A.

Classroom Analysis

Individual classroom groups displayed unique results when analyzed as separate groups as seen in Figure 1B and Table 2. Classrooms 1, 3, and 4 had higher scores after 10 minutes of exercise, and Classroom 3 also had improvements after 5 minutes of exercise.

Student Characteristics Analyses

There was a significant interaction between the exercise dose and gender ($p = .0002$). Both boys and girls improved time-on-task after 10 minutes, but boys had lower time-on-task after 5 minutes while girls had higher time-on-task. No other overall interactions were significant. The individual estimates and linear contrast comparisons can be seen for each potential modifier in Figure 2.

Discussion

This study was the first to directly compare the acute effects of different durations of classroom exercise breaks on on-task behavior. Classroom exercise breaks improved students' on-task behavior after 10 minutes of exposure with evidence of increased on-task behavior after

20 minutes. Similar to the current study, two previous studies that observed time-on-task after classroom exercise breaks found positive effects in on-task behavior after 10 minutes of classroom exercise breaks (Grieco, et al., 2009; Mahar, et al., 2006). The current study was the first to look at the effects of less than 10 minutes of classroom exercise breaks on time-on-task, and found no change in time-on-task after 5 minutes of classroom exercise. No studies have directly compared the acute effects of physical activity on on-task behavior. When examining other cognitive outcomes, Kubesch et al. found no improvement after 5 minutes of classroom activity but did find cognitive improvements after 20 minutes of a physical education class (Kubesch, et al., 2009).

When the results from individual classrooms were examined separately, different classrooms displayed unique results. Three out of the four classrooms improved on-task behavior after 10 minutes of classroom exercise, one classroom had no changes in on-task behavior, and one classroom also showed improvement after 5 minutes of exercise. The differences between classrooms are not unexpected, as classrooms were tracked, or group based on academic abilities and interests, and previous research has shown differences in responses to exercise based on student characteristics (Mahar, et al., 2006). Future research is needed to confirm and understand which classroom types may benefit from specific durations of classroom exercise breaks. Understanding these differences may be useful for school administrators and teachers in making tailored physical activity recommendations for certain classes. For example, a classroom, such as Classroom 3 in the present study, may be able to benefit from 5 minutes of classroom exercise breaks, while other classrooms need 10 minutes.

Only one classroom had decreased time-on-task after any of the exercise breaks, though the decrease was not statistically significant. During the post-testing of this condition, a teacher

knocked over a bookshelf which caused an obvious disruption and students' attention was diverted. This classroom variation points to the complexity of doing research in uncontrolled settings, where several factors can influence results. Many of these factors cannot be completely controlled for statistically and must be considered in the study design and interpretations of findings.

Beyond classroom variation, interesting findings emerged when the results across all classrooms were stratified by individual student characteristics. Boys were the only group who had a decrease in time-on-task after any exercise. Students with lower IQ, higher fitness, and lower BMI showed improvements in time-on-task after 10 minutes of exercise. Grieco et al. found that children with higher BMI showed greater beneficial effects from a classroom exercise break (Grieco, et al., 2009). Of note, no differences were seen between students based on school engagement or their baseline on-task behavior. These results did not support Mahar et al.'s findings that classroom exercise breaks had the greatest benefits in students who were most off-task (Mahar, et al., 2006). However, the current findings do suggest that on-task behavior can be improved in both the most off-task students and students with low engagement in school, who are the students with greater academic needs. These analyses were not adjusted for the multiple comparisons included in the effect modification analyses and had limited power to detect differences by student characteristics. These are preliminary analyses and more research is needed to understand how physical activity may have unique cognitive effects in different students and how regular classroom exercise breaks will affect student on-task behavior. For example, evidence suggests that students with behavioral control problems, such as attention deficit hyperactivity disorder are deficient in executive functioning skill which includes the ability to inhibit inappropriate response such as off-task behavior (Gapin & Etnier, 2010).

Physical activity has the strongest effects on executive function,(Colcombe & Kramer, 2003) and thus regular exercise may be able to more likely to help students with initial deficiencies in executive function. Overall, the effects of classroom exercise breaks appear to be sensitive to multiple factors.

As a “real world” efficacy study, the intervention was implemented by research staff. Implementation by research staff increased the fidelity of intervention to control the received dose in order study the dose-response relationship. However, classroom exercise breaks delivered by outside staff are not sustainable for widespread implementation; teachers need to be trained to implement these practices. Teachers in the current study reported the willingness to implement similar breaks of short duration (Howie, Newman-Norlund, & Pate, 2014), but future studies will be needed to examine if teachers can implement the same intensity and duration classroom exercise breaks as implemented in this study. While previous studies suggest that it is possible for teachers to implement classroom exercise breaks with preserved fidelity (Donnelly, et al., 2009; Gibson, et al., 2008), efficient and effective physical activity professional development for teachers is needed.

Another limitation is the potential for subjectivity with direct observation. For this study, however, several precautions were taken to maintain objectivity in coding time-on-task including blinding observers to the study condition and using an objective and systematic protocol. While the interobserver correlations were fair, any disagreements between observers were further re-evaluated to reach consensus. While time-on-task is not a perfect proxy for whether a student is paying attention or engaged with the lesson, it is a tangible, observable metric used by teachers in the classroom (Helme & Clarke, 2001; Peterson & Swing, 1982).

With strict curriculums and limited time in elementary schools, administrators and teachers must be creative to integrate physical opportunities throughout the school day. A primary barrier to implementing physical activity in the classroom is teachers' fear that students will not be able to settle back down into the lesson, as acknowledged by the teachers in this study. This study suggests that students do not become more off-task after a brief, high intensity, classroom exercise break, but rather increased their on-task behavior. Teachers may even be able to combine academic content with these short breaks (Donnelly, et al., 2009).

Human Subjects Approval Statement

This study was approved by the University of South Carolina Institutional Review Board (IRB Number: Pro00010652) and the research review board of the participating school district.

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Figure Captions

Figure 1: Observed time-on-task after 10 minutes of seated classroom activity or 5, 10, 20 minutes of classroom exercise breaks in A) Total group, B) Each classroom individually (adjusted for gender and pre-test time-on-task)

Figure 2: Time-on-task after seated classroom activity or 5, 10, 20 minutes of classroom exercise breaks, stratified by baseline characteristics (adjusted for gender, classroom group and pre-test time-on-task)

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