Physically Active Academic Lessons and Time on Task: The Moderating Effect of Body Mass Index

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ABSTRACT

GRIECO, L. A., E. M. JOWERS, and J. B. BARTHOLOMEW. Physically Active Academic Lessons and Time on Task: The Moderating Effect of Body Mass Index. Med. Sci. Sports Exerc., Vol. 41, No. 10, pp. 1921–1926, 2009. Physically active classroom lessons have been found to increase on-task behavior in children. Given that physical activity has been associated with an increased time on task (TOT) and that overweight children take fewer steps than normal weight children do, it was expected that benefits of the physical activity would differentially impact those children of higher weight status. Purpose: To examine the effects of a physically active classroom lesson and body mass index (BMI) category on TOT in a sample of elementary-aged children (N = 97). Methods: Behavior was assessed through direct observations before and after a physically active classroom lesson and before and after a traditional inactive classroom lesson. TOT was calculated through momentary time sampling for each student by dividing the number of on-task observations by the total number of observations per student (interrater reliability = 94%). Results: TOT decreased significantly from before to after the lesson for all BMI categories in the inactive control condition, with no change for the active condition. Post hoc analyses found a significant linear effect for the reduction in TOT with each level of BMI in the inactive condition, with the greatest magnitude of effect for the overweight group. Conclusions: Physically active classroom lessons provide a buffer to prevent the steep reduction in TOT experienced after a period of inactivity in all children, especially those who are overweight.

Key Words: CLASSROOM, SCHOOL BASED, PHYSICAL ACTIVITY, CHILDREN, OVERWEIGHT, BEHAVIOR

Classroom-based physical activity lessons use movement in the teaching of core concepts. They are designed to increase physical activity among elementary school children without sacrificing academic instruction time. These lessons provide additional periods of moderate-to-vigorous physical activity during the school day (e.g., [17,10,12,13]). Given this success, it is surprising that few studies have examined their impact on academic-related outcomes. One exception is the work by Mahar et al. (13), which tested the effects of active lessons on subsequent attentional focus in a sample of third and fourth grade children. Attentional focus was operationalized as the time spent observed on the assigned academic task. Results indicated that in comparison to a traditional inactive classroom lesson, the time spent focused on their academic task increased by 8% in the period immediately after completing the physically active lesson. These results mirror the work with general, non–academic-related movement, for example, additional periods of recess or structured play. These studies indicate that behavior (5,11,13) and academic performance (e.g., increases in learning and grades) (15,16) improve with physical activity. If physically active lessons do, in fact, produce enhanced attentional focus in subsequent academic periods, this may provide added motivation for teachers to implement these lessons.

It is not clear that these benefits will be universal for all children. For example, children classified as overweight and at risk for overweight are less physically active than children classified as normal weight (6). In addition to a lack of physical activity, overweight has been associated with several negative school-related outcomes. Body mass index (BMI) has been found to have a negative association with academic achievement (2), and when compared with their normal weight peers, overweight children were found to obtain lower scores on tests of intelligence (1), math, language, and overall grade point averages (14). Overweight children also demonstrate a greater need for remedial classes (18). Given the lower levels of activity and challenges to academic performance, it may be that physically active academic lessons will have a larger impact on the attentional focus of children with a higher BMI. We know of no studies that have
examined the moderating role of BMI on the relationship between physically active lessons and time focused on subsequent academic content.

Accordingly, this study was designed to investigate the differential effects of a physically active classroom lesson and BMI on on-task behavior in children. It was predicted that implementation of a physically active academic lesson would improve children’s time on task (TOT) from before to after the lesson compared with the implementation of a traditional inactive classroom lesson (control condition). In addition, these effects were expected to be magnified in children with higher BMI.

METHODS

Participants. As a part of a larger study, nine third grade classrooms were recruited from an elementary school in central Texas to participate in an in-class physical activity intervention. Written informed parental/legal guardian active consent and child assent were obtained in line with approval from the Institutional Review Board for Research with Human Subjects. Consent and assent forms were returned for 137 (70% participation rate) of 195 children. As a completely within-subjects design, two observational days were required for each student (active and inactive control conditions). Because of listwise deletion of participants, any absence or a missed observation period eliminated a child from all comparisons. Common reasons for missed observations involved school absences or attendance of special instruction outside class. This resulted in a final sample of 97 students.

Design. This study used a 2 (before (pre) and after the lesson (post)) \(\times 2\) (lesson type: active and control) \(\times 3\) (BMI category: normal weight, at risk, and overweight) repeated-measures factorial design. TOT was assessed through 15-min classroom observations before and after (a) a physically active academic lesson and (b) an inactive control lesson. All students completed both lessons, with order of presentation randomly assigned by classroom.

Lessons. The “Texas I-CAN” program was designed to achieve academic curricular goals through movement in the regular education classroom (as opposed to the physical education class). The lessons require 10–15 minutes of moderate-to-vigorous physical activity (MVPA) and are similar to other active lessons (8,13). Lessons covered math, language arts, science, social studies, and health along with general lessons accommodating to any fact-based content. Teachers received a full day of training (8 h) on implementation of the lessons, with a half-day refresher training midway through the school year. The curriculum of lessons was provided to each teacher and outlined the proper procedures, equipment, and space requirements necessary to conduct the lessons. This was designed to ensure lesson consistency across all classrooms. Throughout the year, teachers were asked to track their implementation of the lessons, with a criteria goal of implementing at least one active lesson on 80% of the school days (4 of 5 d wk\(^{-1}\)). Actual implementation rates were higher, i.e., at 91.5%.

Direct observations of I-CAN lessons by trained project staff were conducted to ensure proper lesson implementation by teachers and to verify that students were active at an MVPA level. Furthermore, teachers were required to complete a daily “checklist” reporting the lesson time, duration, quality, ease of implementation, predicted future use, overall rating, physical activity intensity, and student enjoyment. These “checklists” were monitored by project staff to ensure teacher fidelity throughout the duration of the study.

PROCEDURE

Observations. On-task behavior was assessed through TOT and measured through momentary time sampling. In this procedure, members of the research team observed individual children for a duration of 5 s before moving on to another child. This child was, in turn, observed for the same duration before moving on to another child, and so on. After observing each participating child in the classroom, the researchers repeated this sequence for the remainder of the observation period. Decisions regarding the length of each observation within a sweep are based on variations in the behavior under study and the number of children to observe. Generally, this falls within 1- to 30-s observations for each child (9). Although it may be expected that longer observations increase accuracy, longer observations can result in missing the behavior in other children within the sweep. In fact, observations of more than 5 s were found to be less reliable (7). Accordingly, the present observation period was set at 5 s per child, within a total observation period of 15 min. In an effort to maximize the number of observations for each student during the 15-min period, the class was divided into two sections. With 17–22 students per class, this left each observer to rotate observations among 8–11 students. With 180 observations per 15-min period, each student was observed from 16 to 22 times. Although this prevents the ability to collect interrater reliability (IRR) during the study, IRR was measured in separate classrooms at the beginning, middle, and end of the study to ensure that consistent standards were maintained: IRR = 90%, 92%, and 94%, respectively.

After the active lesson or inactive control lesson, students returned to their regular sedentary academic content. All TOT observations took place during this time. Observations were conducted during the academic instruction time of 1:15 to 2:15 p.m. on non–physical education days. Maintaining this consistent observational time ensured that the academic subject area remained the same across all classes (and therefore, students). Students were observed for an interval of 15 min before commencement of the physically active classroom lesson and again for 15 min after completion of the lesson in the experimental condition. The same procedure was completed for the traditional inactive lesson.
Observers were assigned to the appropriate weight category for age and sex in accordance with the CDC “BMI-for-age” growth charts: underweight, <5th percentile; normal weight, between 5th and 84th percentiles; at risk for overweight, between 85th and 94th percentiles; and overweight, ≥95th percentile (3).

Assessment of in-school step count. Observations of activity were not conducted during the study to allow the observers to remain blind to the condition. Instead, we calculated habitual activity during school for these children during a similar set of active lessons. Step counts were collected during a period of 1 wk using a pedometer. An Omron HJ 105 pedometer was placed on the right hip of each participant by a trained project staff member each morning at 7:45 a.m. (the start of the school day) and removed at 2:45 p.m. each day (the end of the school day), at which time the daily step count was recorded (by project staff). Five days is considered sufficient to determine reliable patterns of activity in school (19). Although the assessment of regular activity prevents a meaningful comparison to the single day of assessment of TOT used in this study, it does provide a sense of the sample’s activity levels and how they differ by BMI. As these are merely descriptive and not used to predict the change in TOT, these data from the larger study were considered appropriate to include.

Statistical analysis. TOT was analyzed using a 2 (before [pre] and after the lesson [post]) × 3 (lesson type: active and control) × 3 (BMI category: normal weight, at risk, and overweight) repeated-measures ANOVA. In-school step counts were analyzed using a three-group (normal weight, at risk, overweight) ANOVA on the average steps per day. Effect sizes were calculated for TOT and step count using Cohen’s d statistic.

RESULTS

Descriptive statistics. Of the 137 students sampled, 97 completed all four conditions. Reasons for failure to complete all conditions included student absence from school and enrollment in special instructional programs (outside the classroom) during observational periods. The participants’ mean ± SD age was 8.7 ± 0.41 yr, 54.7% of whom were females. Race/ethnicity composition was as follows: 69.3% white, 13.9% Hispanic, 10.9% African American, and 5.8% Asian/Pacific Islander. Participants’ BMI category was as follows: underweight, 0% (n = 0); normal weight, 64%

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<tr>
<th>TABLE 1. Means and SD for step count and BMI.</th>
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<td>Steps per day</td>
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<td>Normal weight (n = 62)</td>
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<tr>
<td>At risk (n = 17)</td>
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<td>Overweight (n = 16)</td>
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* Significantly different from the normal weight group, P < 0.05.

Observer training and reliability. Observers were trained in a separate set of elementary classrooms to prevent contamination of the observations. Training centered on viewing, coding, and recording behavior for 2 wk before commencement of the study, with multiple iterations of observations and discussions involving the research team and classroom teachers. Training was considered complete when IRR (as a mean percentage of a three-way agreement of on-task and off-task behavior scores among the three observers to conduct the study) exceeded 90%. After four training sessions, IRR was established among the observers at 92%. A 3-month follow-up assessment during the last week of observation indicated that reliability remained high, at 94%.

Assessment of BMI. BMI was assessed for all participants by measuring height and weight using a Tanita BWB digital scale and Perspective Enterprises portable stadiometer. An additional measurement was conducted in 10% of the sample to ensure equipment accuracy. BMI was then calculated [weight / height (kg m⁻²)] and participants were assigned to the appropriate weight category for age and sex in accordance with the CDC “BMI-for-age” growth charts: underweight, <5th percentile; normal weight, between 5th and 84th percentiles; at risk for overweight, between 85th and 94th percentiles; and overweight, ≥95th percentile (3).

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<th>TABLE 2. Means and SD for percentage of TOT of students (N = 97).</th>
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<td>Prelesson</td>
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* Significant difference between pre- and postlesson TOT, P < 0.05.
† Significant difference between pre- and postlesson TOT, P < 0.001.
‡ Significant difference from that of the normal weight group, P < 0.05.
In-school step count. Mean steps per day varied as a function of BMI category. Step counts by group decreased with each increasing level of BMI: normal weight, 5654 ± 2106 steps per day, at risk, 4829 ± 1731 steps per day, and overweight, 4405 ± 1716 steps per day. ANOVA for BMI category and step count was significant ($F_{2,92} = 3.09, P = 0.05$). Trend analysis confirmed the inverse linear trend, with step count decreasing at each level of BMI ($F_{1,92} = 6.04, P = 0.02$). Post hoc analyses revealed that the overweight group took significantly fewer steps than the normal weight group did ($P = 0.03$). These data are displayed in Table 1. Effect sizes indicated that the at-risk ($d = 0.43$) and overweight ($d = 0.65$) groups took fewer steps than the normal weight group did.

TOT. Means, SD, and effect sizes (Cohen’s $d$) for TOT are presented in Table 2. A three-way (pre- vs post-observation × lesson type [active vs inactive control] × BMI category [normal weight, at risk for overweight, overweight]) repeated-measures ANOVA compared TOT between observation periods and revealed a significant three-way interaction ($F_{3,94} = 3.64, P < 0.05$). To decompose this interaction, pre–post change scores and separate repeated-measures ANOVAs within the two conditions were calculated. These analyses revealed significant differences between pre- and postlesson TOT in the inactive control lesson condition ($F_{1,94} = 39.40, P < 0.001$; Fig. 1).

TOT decreased significantly from before to after the lesson for all BMI categories in the inactive control lesson condition: normal weight ($F_{1,61} = 7.16, P = 0.01$), at risk ($F_{1,18} = 14.03, P = 0.001$), and overweight ($F_{1,15} = 21.09, P < 0.001$). Trend analysis confirmed the linear trend, with the reduction in TOT increasing with each level of BMI ($F_{1,94} = 10.57, P < 0.01$). This trend is illustrated by the magnitude of the change in TOT by BMI category, namely, normal weight ($d = 0.39$), at risk ($d = 0.68$), and overweight ($d = 1.28$), indicating that a higher BMI category was inversely related to TOT after an inactive lesson. In the active condition, TOT increased slightly after the active lesson, although the difference was nonsignificant ($F_{2,94} = 2.12, P = 0.13$).

**DISCUSSION**

This study was designed to examine the effects of a physically active classroom lessons on on-task behavior and the role of BMI in this effect. Results indicated that the students’ TOT decreased significantly after a traditional inactive control lesson, whereas implementation of a physically active lesson was found to prevent this reduction and provide a small increase in on-task behavior. These results are similar to previous research that demonstrated TOT decreases in the absence of, and increases in the presence of, a physically active lesson. Mahar et al. (13) revealed that TOT significantly increased after active lessons as a part of...
a classroom-based physical activity program but did not, however, examine this as a function of weight status. The present study extends these findings to include the differential impact of the physically active lessons on children of varying BMI status.

The pronounced effect of physical activity on TOT behavior for the overweight children ($d = 1.28$) compared with the normal weight children ($d = 0.39$) may be resultant of the lower overall activity levels of overweight children during the day. Step counts were assessed during similar lessons with overweight children taking significantly fewer steps than their normal weight counterparts. Because overweight children have lower levels of movement overall, this concentrated dose of physical activity may provide a more potent effect for these children. In contrast, the relative benefit of a physical activity intervention may be less potent for the apparently more active, normal weight children. Clearly, this is speculative because physical activity was not assessed in conjunction with the observations of TOT. However, the results are intriguing and support future research to directly assess the relationship between physical activity and TOT in elementary children. In addition, the observation period in the present study was set at 15 min. As it is known that people are typically able to attend to a task for a period of approximately 10 min before experiencing declines in focusing ability, future studies may explore usage of a longer observational period to fully assess the effect of physical activity on focusing ability because an intervention may provide an even greater benefit than demonstrated here.

Although in line with the percentage of overweight in the state of Texas (4), the number of overweight children is relatively small. However, there was a linear relationship between BMI and TOT, and the difference in TOT between normal weight and overweight children was statistically significant. The biggest limitation of the smaller sample size is the inability to test potential mediators. For example, future research should recruit a larger sample of overweight children because this will provide the ability to test the role of variation in physical activity within the sample of children with a high BMI. In addition, future studies should investigate the relationship of physical activity and on-task behavior with respect to academic performance. Although the ability to attend to the task at hand is believed to be integral to learning and academic performance, these relationships should be measured directly in future research.

Despite these limitations, these data significantly add to the extant literature. It is the first study to demonstrate that BMI moderates the impact of physical activity on TOT. These findings have several implications. Modifying student behavior through usage of physically active academic lessons has the potential to greatly enhance learning by both increasing on-task behavior during academic instruction and decreasing behavioral disruptions throughout the school day. The immediacy of these positive behavioral effects may serve to increase motivation among teachers to implement physically active lessons, in conjunction with the well-established focus on the distal benefits associated with physical activity. Thus, in addition to increasing activity, teachers may well use active lessons to modify behavior and maximize learning time among their students. As a result, these findings may be extended to the application of obesity prevention through providing children the dual benefit of improved behavior and enhanced health.

This research was supported in part by National Institutes of Health grant R21 DK071975-02. Results of the present study do not constitute endorsement by ACSM.
REFERENCES


