Elementary Students' Physical Activity Levels and Behavior When Using Stability Balls

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MeSH TERMS
- attention
- child behavior
- motor activity
- schools
- students

OBJECTIVE. Physical activity is positively related to improved student behaviors. Stability balls have been used as interventions to affect student behavior. The objective of this study was to determine whether the use of stability balls elicits more physical activity than the use of regular chairs and whether stability balls positively influence behavior.

METHOD. Participants ($n = 43$ fourth graders) sat on stability balls during class and wore accelerometers. Eight were randomly selected for behavioral observations using momentary time sampling.

RESULTS. Significant decreases in accelerometer counts were found. No obvious difference for on-task behaviors was found between students using stability balls and those using chairs.

CONCLUSION. Stability balls do not necessarily elicit more physical activity than do chairs; however, students accumulate light-intensity physical activity when using them. Classroom behavior was not detrimentally affected by stability ball use; thus, stability balls do not appear to detract from the classroom instructional atmosphere.

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Physical activity has a plethora of benefits for all who engage in it, particularly in relation to health (Centers for Disease Control and Prevention [CDC], 2011; Strong et al., 2005). People who participate regularly have reduced risk of cardiovascular disease, Type 2 diabetes, and cancer; have better weight management and a higher probability of living a longer life; and have improved mental health and mood (CDC, 2011). In addition to these health benefits, physical activity has also been linked to positive academic performance outcomes in children (CDC, 2010), such as academic achievement (grades, test scores), academic behavior (on-task behavior, attendance), and cognitive skills and attitudes (attention, memory, mood). Specifically, research has examined the relationship between physical activity and academic behaviors during school, citing positive outcomes (Mahar et al., 2006; Pellegrini, Huberty, & Jones, 1995).

The physical activity in the aforementioned studies generally refers to aerobic activity and gross motor skill activities such as running at recess and following teacher-led movement in the classroom. However, other research has also demonstrated a positive relationship between light-intensity levels of activity and academic behaviors (Goffreda, 2010; Grieco, Jowers, & Bartholomew, 2009; Hill et al., 2010; Hill, Williams, Aucott, Thomson, & Mon-Williams, 2011).

Along with physical activity and gross motor skill activities, another strategy educators and researchers have used to improve student academic behavior is stability balls (Carrière, 1998; Fedewa & Erwin, 2011; Schilling, Washington, Billingsley, & Deitz, 2003). Positive relationships have been demonstrated between stability ball use and behavior (Fedewa & Erwin, 2011); however, more information is needed about the physical activity levels generated when students use stability balls as chairs. Physical activity derived from sitting on a stability ball may be different from physical activity or energy expenditure elicited from moderate to vigorous aerobic activity or produced when performing gross motor skills. Thus, a deeper look at physical activity derived from sitting on a stability ball may shed light on the connection between this activity and student academic behaviors. If stability balls provide meaningful amounts of physical activity for students (e.g., contribute to light- or moderate-intensity physical activity levels) while concurrently limiting off-task behavior, stability balls may become the seating choice of the future for the majority of elementary classrooms.

Background and Literature Review

Physical Activity and Behavior

Mahar and colleagues (2006) found that after short breaks for activity, called *energizers,* in the classroom, third- and fourth-grade students accumulated more physical activity than those who did not receive energizers but also showed a statistically significant 8% improvement in behavior after energizers. More important, from a classroom teacher perspective, the least on-task students improved on-task behavior by 20% (Mahar et al., 2006).

Teachers also have reported improved classroom behavior of students after classroom physical activity (Lowden, Powney, Davidson, & James, 2001; Maeda & Randall, 2003). After recess-based physical activity, students were less fidgety in class (Pellegrini & Davis, 1993), were more attentive in class (Pellegrini et al., 1995), and demonstrated improved classroom behavior (Barros, Silver, & Stein, 2009).

A growing body of research has indicated that physical activity positively affects hyperactive behaviors, such as in attention deficit hyperactivity disorder (ADHD; Gapin, Labban, & Etnier, 2011). Boys' behavior has been found to significantly improve after a cycling exercise session, regardless of intensity of exercise (Flohr, Saunders, Evans, & Raggi, 2004). In a case study of a 4-yr-old boy with ADHD, his attentive calmness increased from approximately 3 s per trial to approximately 60 s per trial when he was provided scheduled physical activity breaks (Azrin, Ehle, & Beaumont, 2006). Improved student behavior as reported by parents and teachers was found in a randomized controlled study with 10 wk of physical activity sessions offered during lunch 3 times per week (Verret, Guay, Berthiaume, Gardiner, & Béliveau, 2012). In their literature review, Gapin and colleagues (2011) found that current research supports the potential for acute and chronic physical activity to alleviate ADHD symptoms. Thus, physical activity and exercise appear to be viable interventions for improving students' attention and hyperactivity.

Stability Balls and Sensory Strategies

It has been suggested that stability balls in the classroom may be most effective when used to assist with sensory processing characteristics of children (Bagatell, Mirigliani, Patterson, Reyes, & Test, 2010). Some students may be over- or understimulated by their environment, warranting some type of intervention to improve the ability of their brains to process sensory information to prevent outside influences from becoming a distraction. Although many people are able to stimulate more than one sense concurrently to respond appropriately to a particular situation, others need more practice to allow for sensory input, organize that information, and produce an acceptable response. Stability balls elicit more sensory input through the vestibular and proprioceptive systems compared with regular desk chairs (Case-Smith & O'Brien, 2014), in part because they allow children to concurrently sustain an ideal arousal level while being fairly active (Schilling & Schwartz, 2004). Thus, the balls may have more utility than simply serving as a behavioral intervention for children.

Stability Balls and Behavior

As mentioned previously, one type of intervention that has been implemented in the classroom setting to improve student academic performance is the use of stability balls as chairs (Carrière, 1998; Fedewa & Erwin, 2011; Schilling et al., 2003). Several studies have examined the influence of stability balls on behavior and ADHD (Bill, 2008; Fedewa & Erwin, 2011; Schilling et al., 2003). Schilling and colleagues (2003) found a positive effect of stability balls on in-seat behavior of students with ADHD. Fedewa and Erwin (2011) also found positive effects on in-seat behavior in addition to on-task behavior of students with ADHD. In that study, which took place over the course of 12 wk during the school year, student attention levels and hyperactivity also improved. A randomized controlled trial found that disruptive behaviors decreased when students used stability balls as chairs (Fedewa, Davis, & Ahn, 2015). No differences were found, however, in on-task behavior or standardized Northwest Evaluation Associations Measures of Academic Progress test scores (http://www.nwea.org; Fedewa et al., 2015).

The use of stability balls improves student behavior (Fedewa & Erwin, 2011; Fedewa et al., 2015; Schilling et al., 2003); however, whether students are more active on stability balls and whether that activity, or lack thereof, is the element that positively influences their behavior is unknown. Moreover, improved behavior offers an explanation and activity level has implications for teachers allowing students to sit on stability balls during class. Thus, the purpose of this study was to compare the physical activity levels and behavior of elementary students using stability balls with that of a control group seated in chairs. We sought to answer two research questions: (1) Are there differences in physical activity levels between students who use stability balls and those who use the chairs and (2) do students exhibit higher levels of on-task behavior when seated on stability balls?

Method

Participants

All fourth-grade students from two classrooms in a Southeastern public elementary school were invited to participate in this study. The elementary school was selected to participate because of willingness to collaborate and the principal's ability to randomly assign one of the classrooms to use the stability balls. Twenty percent of students received free or reduced-cost lunches. Seventy-six percent of students were White, 11% African-American, 3% Hispanic, 7% Asian, and 3% other. Of the total eligible students (n = 49), 44 (90%) provided parental consent and were able to participate. Because of the limited number of available accelerometers, missing data as a result of absences, and malfunctioning accelerometers, 20 students were removed from the data analysis on physical activity. The university's institutional review board approved all procedures.

Measures

Physical Activity. Participants wore a Computer Science and Applications (Shalimar, FL) actigraph accelerometer for 10 school days. The accelerometers were programmed to record physical activity in 10-s epochs. These devices were selected because they were considered to be accurate and appropriate motion sensors for research with children, and they have been validated with this age group (Janz, 1994; Trost et al., 1998)

Behavior. Four children from each classroom (n = 8)—2 boys and 2 girls—were randomly selected for in-depth behavioral observations. All of the children had parental consent to participate. These behavioral observations were conducted using momentary time sampling (MTS; see Fedewa & Erwin, 2011; Rapp, Colby-Dirksen, Michalski, Carroll, & Lindenberg, 2008). MTS is a procedure wherein every 30 s the observer uses behavioral classifications to code student behavior. In this study, the codes were *on task* and *off task.* Observers carried a stopwatch to record the 30-s time interval and marked their observations in an Excel (Microsoft Corporation, Redmond, WA) spreadsheet for each participant. Similar to prior studies (Fedewa & Erwin, 2011), MTS at 30 s was selected because it has been shown to reduce the number of false positives for duration events (Rapp et al., 2008). Observations using this methodology have been shown to be more valid and reliable across observers. For the current study, observers had a 92% interreliability rate across observations.

Procedures

Before the study, the researchers oriented participants to the accelerometers by having them handle them and practice putting them on and taking them off. On the first day of physical activity data collection, at the beginning of the school day, each participant was given an accelerometer to be used for the duration of the study. Students were instructed to wear it for the entire school day and put it away at the end of the day. Participants were then instructed to participate in normal activities and to avoid tampering with the accelerometer. After school each day, researchers charged the accelerometers for use the next day.

Physical activity data were collected during 10 school days within a 3-wk period (1 wk on, 1 wk off, 1 wk on). Behavioral observation data were collected daily for 30 min in each classroom, one with stability balls and one without. Two undergraduate students who were trained to do MTS observed the 4 randomly selected students in each classroom each day for 5 wk. Thus, the observers collected a total of 25 observation periods for on-task and off-task behavior. Observers were trained to be as discrete as possible (to ensure that the targeted students were not aware they were being observed), and students were told that the observers were there to watch the teacher. Data were collected in early Fall 2014.

One classroom was randomly assigned to the treatment group (n = 23), and one classroom was randomly assigned to the control group (n = 21). There were 14 girls total in the control and treatment classrooms. Of those students, 15 were study participants (7 girls in the control classroom and 8 girls in the treatment classroom) and were equipped with accelerometers.

Data Analysis

Three measures of physical activity (vertical acceleration counts, horizontal acceleration counts, and number of steps) and a measure of on-task behavior were the dependent variables for analysis. Stability ball use in the classroom was the predictor, or independent, variable. Three sets of a mixed-design analysis of variance (ANOVA) were performed to examine whether any differences existed between the control and treatment classrooms for each of the dependent variables over the 2-wk intervention period.

A 2 (time: Week 1 and Week 2) × 2 (intervention: control and treatment group) mixed ANOVA was used to examine the treatment effect on each of the three measures of physical activity (vertical acceleration counts, horizontal acceleration counts, and number of steps), assessed 10 times over 2 wk of the intervention period. On- and off-task behavior of the 4 students in each of the control and treatment groups was also observed. All underlying assumptions (normality, sphericity assumption for within-subject factor [time], and homogeneity of errors for between-subject factor [intervention]) were checked, and the necessary statistical adjustment was made when these assumptions were violated.

Results

Physical Activity and On-Task Measures

Table 1 displays the physical activity data from the accelerometers for the treatment and control groups. Percentage of time on task and means from the observational data are presented in Table 2.

Intervention Effect on Physical Activity Levels

Table 3 summarizes the statistical results of the intervention effect on students' physical activity levels for vertical accelerometer counts, horizontal accelerometer counts, and number of steps. A significant mean difference was found from Week 1 to Week 2 (*Time* in Table 3; $p < .05$) for each physical activity measure. Students in both the control and the treatment groups showed a significant decrease in vertical accelerometer counts in Week 2 (mean [M] = 51.26, standard deviation [SD] = 38.11) compared with Week 1 (M = 79.56, SD = 46.36), $F(1, 1) = 39.41$, $p < .05$, $\eta_p^2 = .64$. Students in both groups showed a significant decrease in horizontal accelerometer counts in Week 2 (M = 62.45, SD = 27.41) compared with Week 1 (M = 103.92, SD = 95.76), $F(1, 1) = 5.35$, $p = .03$, $\eta_p^2 = .20$. Students in both groups showed a significant decrease in step counts in Week 2 (M = 2,975.82, SD = 1,611.20) compared with Week 1 (M = 4,242.01, SD = 2,006.16), $F(1, 1) = 34.86$, $p < .01$, $\eta_p^2 = .61$.

Intervention Effect on On-Task Behavior

Figure 1 shows the average percentage of on-task behaviors of the 4 students observed in each of the control and treatment classrooms. No obvious difference in on-task behaviors between the students in the treatment and control classrooms was found as a result of using the stability balls in lieu of chairs.

Discussion

The purpose of this study was to examine physical activity levels and behavior of elementary students using stability balls compared with students using chairs. We found that the stability balls did not elicit significantly more physical activity throughout the school day than chairs and that activity levels decreased overall during Week 2 of the study. These findings may be the result of the participants' initial reactivity (i.e., student awareness) to wearing accelerometers to track their movements. Although such reactivity has

Table 1. Physical Activity Measures

Time	Measure	Min	Max	*M*	*SD*
		Control (n = 12)			
Week 1	Steps	2,723.00	5,709.80	3,698.58	939.38
	Vertical accelerometer counts	40.60	105.90	65.48	19.25
	Horizontal accelerometer counts	58.40	127.70	87.08	23.28
Week 2	Steps	1,229.80	4,301.40	2,722.25	795.79
	Vertical accelerometer counts	18.70	73.90	42.72	14.44
	Horizontal accelerometer counts	34.30	102.90	66.22	21.41
		Treatment (n = 12)			
Week 1	Steps	1,907.20	11,961.00	4,785.43	2,624.59
	Vertical accelerometer counts	35.80	266.10	93.64	60.75
	Horizontal accelerometer counts	39.20	537.00	120.75	134.22
Week 2	Steps	276.20	8,080.00	3,229.38	2,157.39
	Vertical accelerometer counts	5.80	204.20	59.81	51.66
	Horizontal accelerometer counts	7.30	127.40	58.69	32.89

Note. M = mean; Max = Maximum; Min = Minimum; SD = standard deviation.

Table 2. Percentage of Time Spent On Task

Observation Period	Control Group (n = 4) Min	Max	*M*	*SD*	Treatment Group (n = 4) Min	Max	*M*	*SD*
1	65	92	75	12	67	88	79	9
2	68	96	81	12	81	97	92	7
3	74	93	83	9	82	98	89	7
4	87	93	89	3	70	95	87	12
5	85	97	91	5	85	98	94	6
6	79	96	88	9	80	100	93	9
7	83	98	93	7	84	98	93	6
8	81	98	89	7	80	95	91	7
9	80	93	85	6	77	95	88	8
10	95	100	98	2	75	97	90	10
11	65	95	82	15	82	98	90	9
12	81	96	92	7	83	97	92	6
13	80	100	89	9	81	98	92	8
14	60	95	84	16	85	97	92	5
15	70	97	81	14	67	98	89	15
16	77	98	85	9	80	95	90	7
17	85	95	91	4	60	97	83	16
18	87	97	93	4	58	98	85	18
19	85	97	92	5	82	95	89	6
20	84	96	91	6	68	100	91	15
21	82	100	88	8	75	93	85	8
22	82	95	91	6	72	97	87	11
23	88	100	94	5	92	100	96	3
24	78	98	90	9	82	100	93	8
25	55	98	84	20	80	98	93	8

Note. *M* = mean; Max = maximum; Min = minimum; *SD* = standard deviation.

been shown not to occur when children wear pedometers (Vincent & Pangrazi, 2002), no studies have assessed whether reactivity occurs with accelerometer wear.

Despite the reasons for these findings, the lack of activity levels while using stability balls is not necessarily a negative outcome. From a physical activity promotion standpoint, these results do not suggest that stability balls will increase physical activity levels. However, from an educational standpoint, these findings may be useful because many classroom teachers observe that the daily school schedule (e.g., core content all morning, then lunch, recess, and special classes in the afternoon) negatively affects their teaching (Cothran, Kulinna, & Garn, 2010). Therefore, use of stability balls in the classroom would not cause an increase in student activity, causing a distraction while teachers are instructing.

Students were engaged in light intensity levels of physical activity while on stability balls (on average, vertical accelerometer count of 79.6 for Week 1 and 51.3 for Week 2 and horizontal accelerometer count of 103.9 for Week 1 and 62.9 for Week 2). These intensity levels were based on Freedson, Melanson, and Sirard's (1998) algorithm. Activity intensity level cutpoints in accelerometers are *sedentary physical activity* (0–8.2), *light physical activity* (8.3–162), and *moderate to vigorous physical activity* (≤163). As a whole, students averaged 4,242 steps per school day in Week 1 and 2,976 steps per school day in Week 2. Although the steps accrued by the students in the current study may be statistically insignificant, the steps counted in this study were practically significant and help contribute to overall steps, as observed by Tudor-Locke et al. (2011), of 10,000–16,000 in a day for children (6–11 yr). At this level, student activity does not appear to pose a distraction to teachers during instructional time.

Similar to the physical activity findings, students seated on stability balls did not differ in on-task behavior from those sitting in chairs. Although previous studies on stability balls in elementary classrooms have found that students exhibit better on-task behaviors while sitting on the balls as opposed to chairs (Fedewa & Erwin, 2011; Fedewa et al., 2015; Schilling et al., 2003), the students in this study were very well behaved overall with few incidences of off-task behavior. Over 25 observation periods, the lowest percentage of on-task behavior was 55% and the highest was 100%. No statistical significance was found between control and treatment groups because both groups were well behaved. Therefore, the stability balls did not negatively influence students' classroom behaviors, which is of concern to many teachers (Lewis, 1997).

The current study may prove promising for people working with students with high levels of inattention and hyperactivity because stability balls may be a possible tool for allowing students to engage in light physical activity without disrupting the rest of the class or the teacher. However, because the lack of significance in behavior between the groups could be attributed to the short duration of the study, more research in this area is necessary.

Limitations

This study had several limitations, including small sample size, short duration of data collection, and lack of a randomized controlled trial. Future studies should examine physical activity levels and behavior of a larger sample of students. Varied age groups would also add to the literature to determine which populations may be most positively affected by the use of stability balls. Although this study did not collect data for a prolonged period of time, previous studies have demonstrated the utility of stability balls for on-task and in-seat behavior in elementary students within a similar time frame (Fedewa & Erwin, 2011). However, perhaps a longer evaluation period would more accurately assess whether differences

Table 3. Mixed-Design Analysis of Variance on Physical Activity Measures

Source	*SS*	*MSE*	*F*	*df*	*p*	η_p^2
Vertical Accelerometer Counts						
Time	9,608.90	9,608.90	39.41	1	<.05	.64
Time × Group	367.07	367.07	1.51	1	.23	.06
Error (time)	5,363.52	243.80		22		
Group	6,140.47	6,140.47	1.90	1	.18	.08
Error (group)	70,959.88	3,225.45		22		
Horizontal Accelerometer Counts						
Time	20,632.82	20,632.82	5.35	1	<.05	.20
Time × Group	5,091.83	5,091.83	1.32	1	.26	.06
Error (time)	84,888.10	3,858.55		22		
Group	2,050.55	2,050.55	0.33	1	.57	.02
Error (group)	136,172.52	6,189.66		22		
Steps						
Time	19,238896.04	19,238,896.04	34.86	1	<.05	.61
Time × Group	1,008,214.24	1,008,214.24	1.83	1	.19	.08
Error (time)	12,141,969.50	551,907.70		22		
Group	7,622,348.60	7,622,348.60	1.28	1	.27	.06
Error (group)	131,501,607.69	5,977,345.80		22		

Note. df = degree of freedom; η_p^2 = effect size measure; *MSE* = mean squared error; *SS* = sum of squares.

in activity occur between students using stability balls and students sitting on chairs. For example, a year-long study could assess activity levels at multiple time points to gauge whether meaningful differences occur in activity levels over time.

Implications for Occupational Therapy Practice

The results of this study have the following implications for occupational therapy practice:

- Because stability balls allow students to accumulate light-intensity physical activity without distracting from the learning environment, classroom teachers should be encouraged to use stability balls in lieu of chairs during instructional time if their goal is adding light physical activity within the school day.
- All activity counts toward overall accumulation, and stability balls allow students to gain a low level of physical activity without negatively affecting their behavior.

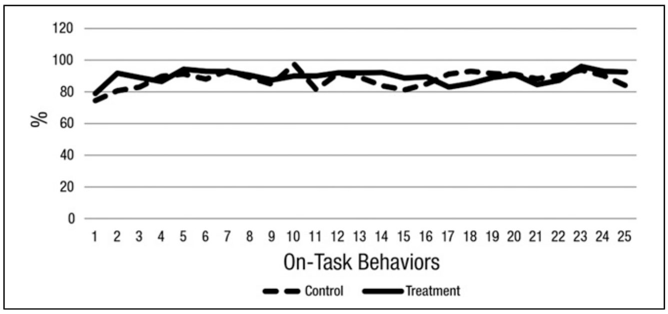

Figure 1. Average percentage of on-task behaviors for control and treatment groups (*n* = 4 for each group).

Conclusion

Results from this study demonstrate that stability balls do not necessarily elicit more physical activity than chairs, but students accumulate light intensity levels of physical activity when using them. Additionally, classroom behavior did not change as a result of using stability balls. Although this finding may be viewed as disappointing, given the positive in-seat findings from prior studies, stability balls do not appear to detract from the instructional atmosphere in a classroom setting. ▲

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