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The Impact of Stability Balls, Activity Breaks, and a Sedentary Classroom on Standardized Math Scores

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Abstract

The purpose of the study was to determine if standardized math test scores improve by administering different types of exercise during math instruction. Three sixth grade classes were assessed on the Measures of Academic Progress (MAP) and the Minnesota Comprehensive Assessment (MCA) standardized math tests during the 2012 and 2013 academic year. The MAP standardized test was given at the beginning and end of the academic year. The MCA test was given every spring. The classes used the same math curriculum. Each class had a different math teacher, but each teacher taught the same class all year. One math classroom (n=23) did no physical exercise during instruction, another (n=29) conducted two 5-min physical activity breaks during each math period, and the third math classroom (n=29) always sat on stability balls. A one-way ANOVA was computed for both MAP and MCA improvement scores across the three classrooms to determine if exercise affected standardized math test scores. MAP improvement scores were significantly higher for the class that sat on stability balls (mean = 11.6, SD = 6.9) when compared to the sedentary class (M = 5.5, SD = 7.0). MCA

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improvement scores were also significantly higher for the stability ball class (M = 104.9, SD = 19.7) when compared to the class that conducted activity breaks (M = 92.6, SD = 7.4). The results indicate that stability balls may provide better focus for learning than short duration vigorous physical activity or no physical activity during math instruction.

Over the last 20 years, stability balls have become popular among fitness professionals and exercise enthusiasts in strengthening the abdominal core, working on balance and posture, and introducing variety to workout routines. Workplaces have also incorporated stability balls as replacements for standard desk chairs to provide exercise opportunities for employees. A more active workforce may experience lower health-care costs associated with diseases linked to excessive daily sitting at work (Owen, Bauman, & Brown, 2009). In Europe, many grade schools long ago replaced standard desk chairs with stability balls (Illi, 1994). Stability balls have been useful in improving fitness and providing support for the trunk, legs, and feet during abdominal exercises (Zipes, 2005) and during therapeutic exercise for children (Witt & Talbot, 1998).

A growing body of research supports the notion that exercise can improve grade school academic performance (Castelli, Hillman, Buck, & Erwin, 2007; Dwyer, Sallis, Blizzard, Lazarus, & Dean, 2001; Stevens, To, Stevenson, & Lochbaum, 2008; Wittberg, Cottrell, Davis, & Northrup, 2010), even in the academic core areas of math (McNaughten & Gabbard, 1993) and reading (Mead, Roark, Larive, Percle, & Auenson, 2013). Additionally, incorporating short physical activity breaks during academic instruction are believed to help meet exercise guidelines for children (Wadsworth, Robinson, Beckham, & Webster, 2012) and may help children learn (Castelli & Ward, 2012). However, no research has investigated whether stability balls can produce the same grade school academic gains as formal exercise. Classroom research using this equipment has focused on stability balls as therapy for improving on-task behaviors and enhancing classroom participation of students with sensory and communication disorders.

Schilling and Schwartz (2004) studied the sensory processing aspect of autism and proposed that modulating sensory information with therapy balls may improve classroom behavior. Students without autism can effectively regulate sensory information to better attend and interact with others. Students with autism respond differently to sensory input and have difficulty registering, integrating, and modulating their sensory systems, which may lead to lack of attention and disruptive behaviors. To test whether arousal levels can be altered during sitting for students with autism, the researchers replaced standard chairs of four preschool children with immobile stability balls during certain times of the day for a maximum of 10 min each session for 3 weeks. After 2 weeks of observation, the researchers observed a marked improvement in classroom behavior and engagement. Upon removal of the balls, an immediate decline in classroom behavior and engagement was observed. In this study, the stability balls appeared to have provided students with autism a means to move while seated, thereby attaining an optimal state of arousal. Bagatell, Mirigliani, Patterson, Reyes, and Test (2010) expanded on the work of Schilling and Schwartz by using the Sensory Processing Measure: Main Classroom Form and video cameras to assess frequency of behaviors of six boys with autism in a kindergarten through first grade class. In this study, the benefits of using stability balls was found to depend on the type of sensory processing disorder. Stability balls were to found to be more appropriate for children who seek vestibular-proprioceptive input when compared to other sensory processing disorders.

In an earlier research study, Schilling, Washington, Billingsley, and Deitz (2003) investigated whether stability balls improved in-seat behavior and legible word productivity of students with attention deficit hyperactivity disorder (ADHD). Three students in a fourth grade inclusive language arts classroom were used in data collection. In-seat behavior was defined as behavior when the student's buttocks was in contact with the ball and both feet and ball were touching the floor. Ten-second observations were conducted over five 2-min periods. Legible word productivity was defined as the difference between the child's legible word production and the class average on the same assignment. All classroom students, including those without ADHD, received stability balls. A 1-week novelty period was provided where students became accustomed to the balls before the observation period occurred. All three participants with ADHD improved sitting behavior and legible word production. Students without ADHD were not observed for in-seat behavior. One participant improved in-seat behavior because the ball provided a means to rock or bounce which may be explained by the ability to meet changing sensory needs of the task and environment. A second participant improved because a standard chair produced extreme postures that were not possible on a ball since one foot always needed to be in contact with the ground. The third participant improved because the ball prevented the student from falling asleep, which often occurred on a standard chair.

The functional performance of students with ADHD while seated on a stability ball has been further investigated by analyzing their electroencephalography (EEG) and reaction time (RT) during auditory tasks (Wu et al., 2012). These researchers investigated whether a stability ball was an effective means of integrating the sensory systems of proprioception, touch, and vestibular. Gentle rocking, swinging, bouncing, at times aided by stability balls, is often used by therapists to assist a child in sensory integration. Children with ADHD have disturbances in brain activation during cognitive tasks that include slower latencies and ineffective event-related brain potentials (ERPs; Senderecka, Grabowska, Szewczyk, Gerce, & Chmylak, 2012). Fifteen children with ADHD were compared to 14 children without disability on a RT task where participants pressed a response button upon hearing a high-frequency auditory signal. Students were told to ignore low-frequency signals. RT and EEG readings were recorded during the task. Children without disability scored faster RT than children with ADHD, but students with ADHD had statistically faster RT while seated on a stability ball versus a standard chair. The RT difference between the two groups of participants also decreased when introducing the stability ball. The stability ball helped alleviate the difference between the two groups of students. The stability ball appeared to activate the proprioceptive and vestibular systems, thereby helping the students modulate task sensory information and better focus on responding to the auditory stimulus (Wu et al., 2012).

Kilbourne (2009) conducted one of the few published studies on the effectiveness of stability balls using only students without a disability. The target population was college students in a one hundred level history and philosophy of sport class. Academic performance was not assessed, but attitudes toward the balls indicated that enthusiasm was present during usage. Participants in the study commonly reported that the balls made them pay more attention, concentrate, and stay engaged during instruction. Posture and activating lower body muscles were also frequently reported. Al-Eisa, Buragadda, and Melam (2013) similarly investigated the effectiveness of stability balls among 40 Saudi physical therapy college students. The focus was on seating discomfort and problem-based learning. Participants reported less musculoskeletal discomfort in the Cornell Musculoskeletal Discomfort Scale while seated on the stability ball when compared to sitting in traditional desk chairs. Additionally, participants were given a questionnaire addressing attitudes about the usage of stability balls during class. Respondents reported higher class participation, comprehension, cooperation, and attention while seated on a stability ball.

The effectiveness of stability balls in fostering attention and engagement of students is evident in the studies cited. However, based on the research, this has been generally found among students with disabilities. Surprisingly, the effectiveness of stability balls in improving actual academic performance for general education students is lacking in inquiry. No published research has investigated whether stability balls can improve core areas of reading, writing, science, and math. The purpose of this study was to compare academic performance (standardized math test scores) of sixth grade math students at an elementary school in St. Paul, Minnesota, between those who use stability balls to those who exercise during class instruction and those who maintained a sedentary learning environment. The particular school was chosen because of its diversity, urban location, and funding to provide exercise equipment to students during instruction.

Method

Expo Elementary is a PreK–6 grade elementary school in an urban area of St. Paul, Minnesota. The enrollment during the 2012–2013 academic year was 763 students. The school maintains a diverse student body with 1% American Indian, 10% Asian American, 23% African American, 8% Hispanic American, 59% Caucasian American, and 13% English Language Learning. Twelve percent of students qualify for special education, and 35% of the students are eligible for free and reduced lunch. Based on standardized testing, the percentages of students in sixth grade in the spring 2013 who were proficient in reading and math were 79% and 58%, respectively.

Participants

This project was approved by the University of St. Thomas Institutional Review Board (IRB #379238-1). Parental consent and child assent was obtained. Expo Elementary has three sixth grade math classes, and all were involved in the study. The students in each class were assigned randomly to each classroom at the beginning of the school year. No students involved in the data analysis had special needs. All three classes held math from 8:40 a.m. to 10:00 a.m. every day of the week. The sixth grade class that sat on stability balls (STAB) had an enrollment of 29 students. The sixth grade class that implemented activity breaks (ACTB) contained 29 students also, and the sedentary class (SEDC) had an enrollment of 23. The ages of all participants was 11 or 12 years of age. Thirteen girls were in the STAB class, 16 in the ACTB class, and 13 in the SEDC class. The STAB class was 52% Caucasian, 28% African American, 7% Hispanic, 7% Asian, and 7% Native American students. The ACTB class consisted of 48% Caucasian, 28% African American, 14% Hispanic, and 10% Asian students. SEDC contained 39% Caucasian, 26% African American, 13% Hispanic, 17% Asian, and 4% Native American students. The STAB teacher had 20 years of elementary education experience, whereas the ACTB and SEDC teachers both had 15 years of elementary education experience each at the time of the study.

Apparatus

The Minnesota Comprehensive Assessments (MCAs) are state achievement tests in mathematics, reading, and science that meet the requirements of the federal Elementary and Secondary Education Act (ESEA). They are given every year to measure student performance against the Minnesota Academic Standards that specify what students in a particular grade should know and be able to do. The State of Minnesota requires that all students in public schools participate in the statewide assessment program. Mathematics and reading tests are given in Grades 3–8 and high school (students in Grade 10 take the Reading MCA and students in Grade 11 take the Mathematics MCA). The Science MCA is given to students in Grades 5 and 8 and in the high school grade when they take a life science or biology course (MN Department of Education, 2013a). The test is administered every spring in late April. Scores range from G01 to G99 where "G" represents grade level of the test taker. All students in this study automatically increased their math MCA scores by 100 points merely by moving from fifth grade to sixth grade. At the sixth grade level, a score of 661 or higher meant the student exceeded the math standards. A score range of 650–660 meant the student met the standard. A 640–649 score range meant partially met, and below 640 meant the student did not meet the math standards (MN Department of Education, 2013b).

The Measures of Academic Progress (MAP) is a standardized test that assesses reading, mathematics, and language for Grades 3–12. It is a computerized assessment that adapts to responses to test questions and to the child's skills and knowledge. The content of the exam changes as the student answers correctly or incorrectly. Results are based on an equal interval scale to determine proficiency level, instructional readiness, and selection of instructional resources to best meet the student's ability. The outcome data identifies the differentiated instruction needed for the child, flexible grouping for instruction, and proficiency projections on how the student will perform on state assessments. The math portion covers problem solving, number sense, computation, measurement and geometry, statistics, probability, and algebra. For sixth graders, a fall MAP math score of 220 or better was considered above grade level, at grade level was a score of 219, and a score at 218 or lower meant below grade level. Spring MAP scores required a score of 226 or higher to be considered above grade level, 225 meant at grade level, and a score lower than 225 was considered below grade level (Northwest Evaluation Association, 2013). The test was administered the beginning of October 2012 and the end of May 2013.

The stability balls were purchased from Wittfitt Learning in Motion. The balls were made in Italy from PVC material. Each ball was 55cm, which was the recommended size for children up to sixth grade. The balls were inflated to different loads in order to fit the varying heights of the children in the classroom so that they could all sit with feet flat and knees and hips bent at 90 degrees of flexion.

Procedure

A three independent group pretest–posttest design was used with one class serving as the control group. Difference scores of the pretest and posttest MCA and MAP scores were calculated and then compared across three independent classrooms. All sixth grade students at Expo Elementary completed the same block sequence of courses in math, science, and reading and writing. In these core subjects, each class duration was 80 min. Math began at 8:40 a.m., followed by science at 10:00 a.m., music or physical education at 11:45 a.m., recess and lunch at 12:35 p.m., and reading and writing at 1:20 p.m. The scope and sequence for math, reading and writing, and science was the same for all three classrooms.

The math curriculum that was implemented at Expo Elementary was called Every Day Math (University of Chicago School Mathematics Project, 2012). Each math class conducted 4- to 6-week units on the math topics of collection, display, and interpretation of data; operations with whole number and decimals; variables, formulas, and graphs; rational number uses and operations; geometry: congruence, constructions, and parallel lines; number systems and algebra concepts; probability and discrete mathematics; rates and ratios; more about variables, formulas, and graphs; and geometry topics. Each math class was divided into an opening segment (25 min) and a work time segment (55 min). The ACTB class had 10 min less of work time since a total of 10 min was devoted to physical activity. During the opening segment, students would be presented first with a math message and a problem to solve. This would be followed by mental math exercises, then reviewing concepts and homework, and finally an introduction to the lesson for the day. The last 55 min of the math class would be devoted to work time where students would work in small groups or receive assistance from the math teacher.

Each of the math classes was assigned to one of three treatments: activity breaks (ACTB), stability ball (STAB), and sedentary (SEDC). In one math class (ACTB), 5-min physical activity breaks were implemented and occurred immediately after the math message and immediately prior to the beginning of work time. Five-minute activity breaks were based on research indicating that children should be active for 5 to 10 min following a 60-min period of inactivity. Additionally, the benefits of exercise last between 40 and 60 min (Castelli & Ward, 2012). To get the students aroused and moving, the ACTB teacher would pick a student to roll a dice three times. Based on the dice numbers rolled, all students would have to perform the corresponding activities for 30 s each. At the end of 30 s, students would perform the next activity corresponding to the dice roll. After 1.5 min, students would then perform the next set of activities corresponding to the dice roll. This process would continue until 5 min were up. Table 1 lists the physical activities corresponding to the dice rolls. Students had the option to not participate in the physical activities but only rarely did a student choose to stay seated during this time.

Table 1
Exercises Completed in the ACTB Class Based on Roll of the Dice

Target area	Strength exercises	Dice roll	Cardiovascular exercises	Dice roll
Upper Body	pushups tight arm circles plank	1	speed bag punches big arm circles	2
Lower Body	step-ups squats lunges	3	running in place log jumps high knees	4
Both	burpees sit-ups bicycles	5	jumping jacks mountain climbers jump rope	6

The STAB teacher removed all chairs at the start of the school year and replaced the standard desk chairs with appropriate-sized stability balls so that all students could sit on the ball such that the student's back was straight, hips and knees bent at 90 degrees, and feet were able to lay flat on the floor. The STAB teacher did not incorporate any other physical activity during math class. The SEDC teacher taught without implementing any physical activity at any time of the year during math class time.

Results

There were four students who did not complete both a MAP pre- and posttest (STAB = 2, ACTB = 1, SEDC = 1). For the MCA tests, two students in STAB and SEDC along with five students in ACTB did not complete pretests and posttests. Reasons for not having both test scores were absences during testing, a student could not complete the general test because of disability, and moving between schools during the timeframe of this study. Students with a missing pretest or posttest score could not be used to determine effectiveness of the interventions. SPSS version 19 was used for all data analysis.

A one-way ANOVA was computed to determine if the three classes differed on the pretests. The MAP pretest (fall 2012) math scores were not significantly different between the three classes, $F(2, 79) = 3.1$, $p = .052$. Similarly, the MCA math pretest scores (spring 2012) were not significantly different between the three classes, $F(2, 76) = 2.37$, $p = .10$. Table 2 provides the means and standard deviations of the MAP and MCA scores for the three classes. MAP and MCA posttest refers to the spring of 2013 test scores. Table 2 includes all student test score means and standard deviations including those students who may have not taken both a pretest and posttest. Table 3 indicates the percent of students in each class who met the standards for both the MAP and MCA pretests and posttests.

To determine if the interventions had an effect on standardized math test scores, a one-way ANOVA was computed on difference scores (posttest–pretest) for both the MAP and MCA tests. For the MAP test, a significant main effect was computed on difference scores, $F(2, 76) = 4.1$, $p = .021$, across the three classes. A Tukey post hoc analysis indicated that difference scores were significantly higher ($p = .016$) for the class that sat on stability balls (STAB; $M = 11.6$, $SD = 6.9$) when compared to the sedentary class ($M = 5.5$, $SD = 7.0$) but not significant ($p = .254$) when compared to the class with activity breaks ($M = 8.4$, $SD = 8.0$). A Cohen's d was then calculated between STAB and SEDC ($d = .88$), indicating a large effect size. ACTB and SEDC did not differ on MAP difference scores ($p = .367$) according to the post hoc test. Males did not differ from females on the MAP difference scores, $F(1, 76) = .007$, $p = .933$.

Table 2
MCA and MAP Scores for the Three Sixth Grade Classrooms

	MAP pretest (fall 2012)		MAP posttest (spring 2013)		MCA pretest (spring 2012)		MCA posttest (spring 2013)	
Classroom	***n***	***M* (*SD*)**	***n***	***M* (*SD*)**	***n***	***M* (*SD*)**	***n***	***M* (*SD*)**
STAB	28	228.3 (11.7)	28	238.7 (12.1)	28	532.3 (31.6)	28	636.4 (34.5)
SEDC	23	221.2 (16.0)	22	226.0 (15.1)	22	543.9 (13.1)	22	643.1 (12.4)
ACTB	28	219.7 (14.0)	28	226.8 (15.1)	26	527.3 (29.8)	25	620.9 (34.2)
Total	80	223.1 (14.2)	78	230.8 (15.1)	76	533.8 (27.4)	75	633.1 (30.8)

Table 3
Percent of Students for Each Class Meeting the MAP and MCA Requirements

	STAB		ACTB		SEDC	
Standardized test	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**
MAP						
Above Grade Level	82	86	50	57	57	55
At Grade Level	0	0	4	0	4	5
Below Grade Level	18	14	46	43	39	40
MCA						
Exceeded Standard	32	36	31	20	9	5
Met Standard	29	36	12	16	27	32
Below Standard	39	28	57	64	64	63

For the MCA test, a significant main effect was calculated, $F(2, 71) = 5.4$, $p = .006$, on difference scores. For the class that sat on stability balls, a Tukey post hoc test showed a significant difference ($p = .004$) between STAB ($M = 104.9$, $SD = 19.7$) and the activity break class ($M = 92.6$, $SD = 7.4$) but not ($p = .19$) the sedentary class ($M = 98.0$, $SD = 6.8$). A Cohen's d was then calculated between STAB and ACTB ($d = .83$) indicating a large effect size. ACTB and SEDC did not differ on MCA difference scores (p = .362) according to the post hoc test. Males did not differ from females on the MCA difference scores, $F(1, 71) = .828$, $p = .366$. Thus, stability balls had an impact on standardized test taking in mathematics.

Discussion

This is the first known study to investigate whether stability balls can yield the same academic benefits as other types of exercise done during, prior, or after instruction. The purpose of the study was to determine if implementing various types of exercise in the core curriculum can positively impact standardized test scores of grade school students in the academic area of math. The three teachers in the study followed the same set math curriculum of instruction, used the same in-class assessments and text, and sought to obtain the same Minnesota K–12 Mathematics Academic Standards (MN Department of Education, 2013c). The scope and sequence for all three classes was exactly the same. The only differences between the three classes were the teacher for each class and the nature of physical activity incorporated during the school day. The three teachers were veterans in implementing effective pedagogical practices. The results of this study indicated that incorporating certain modes of exercise in math class can positively impact standardized test scores. Short physical activity breaks during class time were not effective in improving math scores but continuous low intensity posturing and positioning activities in the classroom using a stability ball were effective.

One explanation why stability ball usage was more effective in influencing academic performance may be that the stability balls resulted in greater alertness and arousal during academic instruction than intermittent bouts of activity or no physical activity. Previous research, mostly among students with disabilities, has indicated that students with certain types of sensory disorders can benefit from stability ball usage (Bagatell et al., 2010). While students in the present study did not have known disabilities of any type, the stability balls do provide vestibular, somatosensory, and proprioceptive stimuli to the user as they control posture and muscle tone necessary to maintain balance in a seated position (Schilling & Schwartz, 2004). By activating these systems, the stability balls may produce a level of awareness, integration, and regulation of sensation that can facilitate learning.

Stability ball use may have improved students' task attention, resulting in greater gains on test scores. Schilling et al. (2003) showed that children with disabilities stayed in their seat when using a stability ball and remained on task. Participants in this study may have found that it was difficult to alter their seated position on a stability ball (i.e., leaning back or to the side to converse with a neighboring student); thus, they remained focused during instruction and/or work time. Moreover, the ball also made it difficult to turn away from the desk to look out the window or at other in-class distractors during class time. Students also undoubtedly found that they could not quickly get out of their seated position on the ball and go off task when the teacher was not looking. Some students gently bounce on the ball during class time, which might stimulate the vestibular, proprioceptive, and somatosensory systems. The activation of these systems on a stability ball appears to facilitate attentional focus and minimize distracting stimuli that interfere with learning.

Several strengths and limitations should be noted. The present study is strengthened by several factors, including the use of state standardized achievement tests, a common curriculum, and teacher experience. The three teachers in each study classroom followed the same set math curriculum of instruction, including in-class assessments and text, and sought to obtain the same Minnesota K–12 Mathematics Academic Standards (MN Department of Education, 2013c). Moreover, the teachers were veterans (minimum 15 years of teaching experience) in implementing effective pedagogical practices. Study interventions were randomly assigned to the three mathematics classrooms. Thus, the differences between the three classes were the teacher for each class and the nature of physical activity incorporated during the school day.

This study did not have access to scores in other academic areas. Comparing stability ball usage in English or reading or science classes may better target where learning could be facilitated. This study is also limited in that two activity breaks were provided during math class. It is unknown if, when, and how many activity breaks are needed to increase learning and retention of subject areas like math, reading, English, and science. Short duration physical activity has been found to increase academic performance (Hillman, Pontifex, Raine, Castelli, Hall, & Kramer, 2009) but not in this study. Taking more than 10 min out of instructional time in order to exercise may be hard to justify to school administrators. Physical activity breaks done during transition times between classes may be more effective and would not take away from valuable instruction time. This study is limited in that each classroom had a different teacher. Although not statistically different, the STAB class had more students meeting the MCA and MAP standards before and after the interventions. Whether this affected improvement scores is unknown. Additionally, intricacies among teachers may have accounted for some of the differences in math improvement scores between the three classrooms. Rotating stability balls between classroom teachers at varying times of the year and then looking at academic test scores may better identify stability ball effectiveness in increasing learning. Last, the ACTB class had 10 min less of actual math work time every day due to the physical activity breaks. It is unknown if this factor negatively affected math scores but no research to date has found that incorporating physical activity hinders academics.

We showed that replacing traditional desk chairs with stability balls improved sixth grade students' standardized test scores in math compared to 5-min activity breaks and no physical activity during math class. This intervention suggests that stability ball use may be a simple, effective means of improving student learning the core academic area of mathematics. This study presents school administrators and teachers, who are under pressure to raise test scores, an alternative option to expensive and timely remediation measures that are currently being employed throughout the United States. Further research is needed to learn whether stability balls may improve other core academic areas like writing, reading, and science. In addition, it is important to understand the physiological processes underlying improved test achievement scores following exercise that was observed in this study. The results of the present study are nonetheless intriguing and highlight the need for more research in this area.

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