Physiology

A Pilot Evaluation of the Effects of Exercise Stability Balls on BMI in the Educational Setting

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Childhood obesity is a significant public health problem, and school-based interventions offer opportunities to reach children. We examined the feasibility of using stability balls, as compared to traditional desk chairs, in elementary school classrooms testing effects on vital signs and BMI. Forty-seven fourth graders from two classrooms participated: twenty-seven using balls and 20 using chairs over a 45 day period from the beginning to the end of the second quarter of school. Overall, children welcomed using stability balls and over 90% reported improvement of the classroom's learning environment. No significant difference was found in BMI percentile (p = 0.726), systolic (p = 0.148) or diastolic (p = 0.747) blood pressure percentiles, or resting pulse (p=0.977) between the two classrooms. *Journal of Nature and Science, 1(6):e117, 2015*

Childhood obesity | weight loss treatment | blood pressure

Introduction

The current "obesity crisis" is believed to be due to the imbalance between adequate nutrition and overconsumption. Although obesity is often thought of as a cosmetic problem, it also greatly increases the risk for other health conditions including coronary artery disease, type II diabetes mellitus, hypertension, hypercholesterolemia, stroke, obstructive sleep apnea, osteoarthritis and cancer, as well as social and psychological problems such as bullying and poor self-esteem [12]. Approximately two-thirds of American adults and more than one-third of children are overweight or obese [14], and for this reason, the life expectancy prognostic factors now include BMI. Moderate obesity reduces life expectancy by about three years, and severe obesity can shorten it by ten years, equivalent to the effects of life-long smoking [8].

It is well known that lifestyle habits, including physical activity, can lower the risk of becoming obese and developing related diseases. Specifically, physical activity can improve BMI, blood pressure and resting heart rate. Therefore, the American Academy of Pediatrics recommends 60 minutes of moderate physical activity daily for elementary-aged children to keep them healthy [1]. Children's dietary and physical activity behaviors are influenced by many sectors of society, including schools. Because children dedicate a large portion of their day in school, this environment plays a particularly crucial role for health promotion by modeling healthy behaviors, including physical activity [11]. Unfortunately, the trend has been for physical education cuts due to budgetary constraints across the country and more rigorous academic curricula, resulting in students becoming less active in school [13].

Although schools can instill the knowledge of the importance of nutrition and cafeterias can offer healthier food choices, students still spend a majority of the day sedentary in the classroom, a key issue in the growing obesity epidemic. For this reason, some educational settings have incorporated the use of a stability ball as a chair to increase physical activity during the school day. Stability balls have been shown to improve strength, range of motion, flexibility, and proprioception [10], while also helping to maintain good posture and back health [5]. These effects are attributed to the fact that stability balls encourage straighter posture and deeper breathing, therefore increasing blood flow and oxygen to the brain resulting in increased attention spans and improved academic success [3].

Previous research has shown that energy expenditure is 4.1 kcal/hour or 6% greater while sitting on a therapy ball compared to sitting in a chair [2], likely due to the increased energy cost of an elevation in heart rate and increased muscle activation to support an upright posture [9]. In addition to the previously studied positive attributes of stability balls, the purpose of this study was to determine if stability balls also positively affect BMI, blood pressure and resting heart rate. To our knowledge, this is the first pilot study to determine whether the use of stability balls in the classroom setting improve health parameters such as BMI, blood pressure and resting heart rate.

Methods

Study Overview: We conducted a feasibility study in 2013 to assess the use of stability balls in elementary students. Forty-seven fourth grade students in two different classrooms at an elementary school in Lebanon, PA participated in this pilot study. Recruitment of the school was chosen because of a teacher who desired stability balls in the classroom. A power analysis was not completed as this study had a small sample size and was designed as a pilot. Both classrooms used chairs during the 1st Quarter (Q), which was 45 days long. At the beginning of the 2nd Q, one classroom of 27 students (Classroom A) switched to stability balls in place of chairs, while 20 students (Classroom B) served as the control group and continued using chairs for an additional 45 days.

Students in Classroom A were given the option to use the stability balls or chairs, all of which chose to participate by using the stability balls. All stability balls were donated to the classroom. They were given the appropriate sized balls based on their height. Students in Classroom A used stability balls for approximately 6 hours per day. Both classrooms received the same amount of recess and gym class time with similar activities each week.

Data assessments were conducted at three times points: (1) beginning of the school year; (2) end of 1st quarter; and (3) end of 2nd quarter. Assessments were conducted by two school nurses who were trained in the measures, which included height, weight, blood pressure and resting heart rate **(Figure I)**. Height was measured using the school stadiometer and weight was obtained using the school's digital scale. Blood pressure was measured by manual sphygmomanometer using the appropriate cuff size. In addition, Classroom A was issued a 45-question survey with answer choices "strongly disagree, disagree, don't know, agree, strongly agree" to determine satisfaction with the use of stability balls at the end of the 2nd Q. BMI was calculated and percentiles were determined using appropriate Z scores.

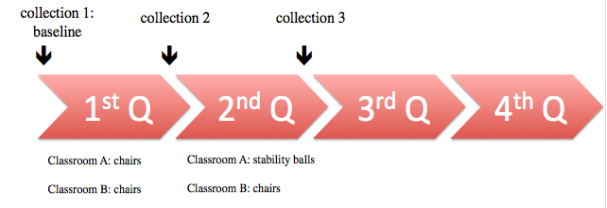

Figure 1. Visual representation of the timeline of data collection.

Conflict of interest: No conflicts declared.

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Table I. Baseline data comparing classroom A (stability balls) and classroom B (chairs).

Variable	Total (N=47)	Chair (N=20)	Stability (N=27)	P-value*
Age 9	44 (97.8)	19 (100.0)	25 (96.2)	1.0
Male	23 (48.9)	9 (45.0)	14 (51.9)	0.642
BMI (%)				
<85th%	34 (74.0)	19 (95.0)	15 (57.7)	0.017
85th%-94th%	6 (13.0)	1 (5.0)	5 (19.2)	
≥95th%	6 (13.0)	0 (0.0)	6 (23.1)	
SBP (%)				
<90th%	40 (87.0)	19 (95.0)	21 (80.8)	0.432
90th%-94th%	3 (6.5)	1 (5.0)	2 (7.7)	
≥95th%	3 (6.5)	0 (0.0)	3 (11.5)	
DBP (%)				
<90th%	39 (84.8)	19 (95.0)	20 (77.0)	0.271
90th%-94th%	3 (6.5)	0 (0.0)	3 (11.5)	
≥95th%	4 (8.7)	1 (5.0)	3 (11.5)	
* P-values from Chi-square test, exact test used with small cell counts as needed				

Table II. Examples of survey questions from students in Classroom A (stability balls) taken after the 2nd Q.

	strongly agree	agree	don't know	disagree	strongly disagree
I like sitting on the ball.	21 (81%)	4 (15%)	1 (4%)	0 (0%)	0 (0%)
I listen best when I sit on the ball.	14 (54%)	7 (27%)	4 (16%)	1 (4%)	0 (0%)
I pay attention more easily when I sit on the ball.	15 (58%)	9 (35%)	2 (8%)	0 (0%)	0 (0%)
I concentrate more easily when I sit on the ball.	18 (69%)	4 (15%)	4 (15%)	0 (0%)	0 (0%)
I enjoy school more when I sit on the ball.	22 (85%)	3 (12%)	1 (4%)	0 (0%)	0 (0%)
Mr. Fulkerson should have balls in the classroom next year.	23 (89%)	2 (8%)	1 (4%)	0 (0%)	0 (0%)

Consent by the principals at Ebenezer Elementary was obtained, and all students and their parents were required to sign a consent form prior to participation in the study. This pilot study was approved by the Institutional Review Board at the Penn State Hershey College of Medicine.

Statistical analysis: All statistical analyses were performed using SAS software version 9.4 (SAS Institute, Cary, NC). Categorical variables were summarized with frequencies and percentages while continuous variables were summarized with means, standard deviations, medians, and quartiles. The distributions of continuous outcome variables were assessed using box plots, histograms, and normal probability plots. Comparisons of demographic variables such as age groups and gender were made between study groups at baseline using Chi-square tests. An exact test was used as needed when cell counts were too small for the Chi-square test to be valid.

In making comparisons within and between study groups from the start of the 2nd Q to the end of the 2nd Q, we used an intent-to-treat (ITT) approach by using all of the available data in the models instead of using only data for those subjects who completed the study and had data at the end of the 2nd Q. A linear mixed effects model that included factors for the study group, time, and interaction between study group and time was employed to make these comparisons, and differences within and between study groups were quantified with means.

Results

Forty-seven fourth grade students were enrolled in this pilot study. Twenty-seven students in Classroom A used stability balls, and 20 students in Classroom B used traditional desk chairs. Almost all of the students were 9 years old in both classrooms and about half of each class were male (p=0.642). Missing data was not an issue as only one subject had missing data at the end of the 2nd Q in either study group (Table I).

In Classroom A 23% were considered obese (BMI ≥ 95th%), 19% overweight (BMI = 85th% to 94th%), and 58% normal weight (BMI < 85%) at the beginning of the study. In Classroom B 0% were considered obese, 5% overweight, and 95% normal weight at the beginning of the study. The average starting BMI percentile was 55.92% in Classroom A and the average starting BMI percentile was 52.0% in Classroom B. In Classroom A, 19% had elevated systolic blood pressure (sBP≥ 90th%) and 23% had elevated diastolic blood pressure (dBP≥90th%). In Classroom B, 5% had elevated systolic blood pressure and 5% had elevated diastolic blood pressure at the beginning of the study (Table I).

All 27 students in Classroom A chose to sit on stability balls in the 2nd Quarter. Over 90% of students in Classroom A reported that they liked sitting on the stability balls, paid attention more, and enjoyed school more with the use of stability balls in the classroom (Table II).

There was no significant difference between the two Classrooms in change in BMI % (p=0.726). There was also no significant difference between the two Classrooms in change in BMI z-score (Table III).

There was no significant difference between the two classrooms in the change in systolic blood pressure percentiles (p=0.148), diastolic blood pressure percentiles (p=0.747), and heart rate (0.977). (Table III).

The eleven overweight and obese children in the stability ball classroom significantly gained a BMI of 0.39 kg/m² (p = 0.047) and a BMI percentile gain of 0.58 (p = 0.026) during the study.

Discussion

There are currently multiple mechanisms underway to target the growing obesity epidemic. Although activity level seems to be at the forefront, a sedentary lifestyle of students in the school setting limits the amount of recommended physical activity throughout the day. In this pilot study, we focused on a novel environmental classroom addition that had the potential to increase physical activity to improve health while also serving as a unique way to maintain the students' focus during class.

To our knowledge, this is the first published report to determine whether lengthy daily use of stability balls could improve a child's BMI and vital signs. We hypothesized that the replacement of desk chairs with stability balls would allow children to expend more energy and therefore improve BMI, blood pressure and resting heart rate compared to their peers who remained stationary throughout the school day.

Table III. Data analysis comparing classroom A (stability balls) and classroom B (chairs).

Variable	Group	Start (N=46) Mean (95% CI)	End (N=45) Mean (95% CI)	End-Start Mean (95% CI)	Within P-value	Between P-value
BMI (kg/m^2)	Chair (N=20)	17.01 (15.34, 18.68)	16.96 (15.25, 18.67)	-0.04 (-0.28, 0.19)	0.707	0.194
	Stability (N=26)	18.76 (17.32, 20.20)	18.92 (17.45, 20.39)	0.16 (-0.04, 0.36)	0.121	
BMI (z-score)	Chair (N=20)	0.05 (-0.49, 0.58)	-0.04 (-0.59, 0.52)	-0.09 (-0.18, 0.01)	0.077	0.288
	Stability (N=26)	0.28 (-0.19, 0.75)	0.26 (-0.23, 0.75)	-0.02 (-0.10, 0.06)	0.650	
BMI (%)	Chair (N=20)	52.0 (37.08, 66.92)	50.42 (35.15, 65.69)	-1.58 (-4.41, 1.26)	0.268	0.726
	Stability (N=26)	55.92 (42.83, 69.01)	55.0 (41.62, 68.38	-0.92 (-3.36, 1.51)	0.449	
Sys BP (mmHg)	Chair (N=20)	98.65 (94.79, 102.51)	101.32 (97.38, 105.25)	2.67 (-2.57, 7.91)	0.311	0.077
	Stability (N=26)	106.89 (103.50, 110.27)	103.32 (99.95, 106.69)	-3.57 (-8.10, 0.96)	0.120	
Sys BP (%)	Chair (N=20)	40.50 (29.67, 51.33)	47.13 (35.29, 58.96)	6.63 (-8.60, 21.85)	0.385	0.148
	Stability (N=26)	60.88 (51.39, 70.38)	52.81 (42.69, 62.93)	-8.08 (-21.23, 5.08)	0.222	
Dia BP (mmHg)	Chair (N=20)	61.90 (58.16, 65.64)	60.21 (56.55, 63.87)	-1.69 (-6.48, 3.10)	0.481	0.945
	Stability (N=26)	66.87 (63.59, 70.14)	65.40 (62.27, 68.53)	-1.47 (-5.61, 2.67)	0.479	
Dia BP (%)	Chair (N=20)	54.85 (44.98, 64.72)	48.53 (37.44, 59.61)	-6.32 (-19.78, 7.14)	0.349	0.747
	Stability (N=26)	65.54 (56.88, 74.20)	62.08 (52.59, 71.57)	-3.46 (-15.08, 8.16)	0.551	
Pulse (bpm)	Chair (N=20)	86.20 (81.53, 90.87)	88.17 (82.89, 93.46)	1.97 (-3.44, 7.39)	0.467	0.977
	Stability (N=26)	86.73 (82.65, 90.82)	88.81 (84.27, 93.35)	2.08 (-2.58, 6.73)	0.374	

* All mean estimates, confidence limits, and p-values are from a mixed model that includes all time points and data for both study groups.

There are scant findings to suggest stability balls increase energy expenditure and improve posture in adults. However, findings may be different in children and therefore this examination of children's BMI while using stability balls, which has yet to be studied, is worthy of investigation.

Prior to data collection, observation of the students further supported this hypothesis because they continually bounced on their balls throughout the day. However, our data showed that there was no significant difference in BMI ($p = 0.194$), BMI percentile ($p = 0.726$), systolic ($p = 0.148$) or diastolic ($p = 0.747$) blood pressure percentiles, or resting heart rate ($p = 0.977$) with children using the stability balls in the classroom compared to those using chairs. Research shows an increased energy expenditure of 4 kcal/hour [2], so at 6 hours per day, this amounts to expending only 125 kcals per week. In addition, research by Lanningham-Foster et al also determined exercise level to be similar in students who used a standing classroom and those who used a traditional classroom setup [7], further supporting the results of our study.

Our data also showed that the students in the stability ball classroom as a whole had no difference in BMI change during the study ($p=0.121$); however, the eleven overweight and obese children in the stability ball classroom significantly gained a BMI of 0.39 kg/m² ($p = 0.047$) and a BMI percentile gain of 0.58 ($p = 0.026$). Therefore, the stability balls did not aid with weight loss for this group of high-risk children and may support the literature that exercise without changes in diet in overweight and obese individuals creates minimal impact on weight loss[15].

Research from the child's perspective of using a stability ball as a chair in the classroom is almost non-existent. Although there were no significant changes in BMI and cardiovascular measures, it should be noted that benefits of the stability balls were reported, including improved attention and enjoyment in the classroom. This finding supports the literature that exercise improves the attention span [4]. One unpublished study in 2008 performed by a college professor showed that his 52 college students viewed that they had an improvement in attention, concentration, discussion and exam-taking skills. Ninety-eight percent of the students stated that they would use the stability balls as a seat if provided the opportunity in the future [6]. However, elementary students are very different from college-age students, suggesting our study is a unique contribution to the literature. Students in Classroom A of our study also reported high satisfaction levels, including enjoying school and paying attention more with the use of stability balls in the classroom **(Table II)**. Further studies are needed to validate these findings with evaluations of attention and academic performance when using stability balls.

A number of limitations of the present study should be acknowledged. First and most significant, this pilot study focused on only two classrooms, so the sample size was underpowered with only about 3 months between data collections. We are unable to explain why the BMI percentile change was actually better (-1.58% versus -0.92%) in Classroom B (chairs only) compared to Classroom A (balls), however, given our small sample size, we were not powered to see a difference for an intervention with a small effect size. An unanticipated concern was that a greater percentage of students in Classroom A were overweight or obese (44% vs. 5%) at the beginning of the study ($p=0.017$) compared to Classroom B. Therefore, this group of overweight and obese children in classroom with stability balls was not appropriately controlled with the children in the classroom with chairs. In future studies, recruitment of many classrooms, thus providing a larger sample size, would likely allow for a powered and randomized study with significant findings. Of course, finding many teachers who agree to have stability balls in the classroom may be an obstacle.

It may be possible that the children of the classroom that used the chairs, which had a lower BMI at baseline, had healthier diets or were more physically active outside of school compared to the students who used the stability balls, thus allowing more of an improvement of BMI percentile in Classroom B. For future research, diet logs, physical activity records and measurement of caloric expenditure with actigraphy, should be considered. Additional resources to fund the study would be required.

In closing, the obesity epidemic has been affecting the lives of our children and greatly impacting their future health, life expectancy and well-being. Increasing the level of physical activity among students can prove extremely beneficial to both the health and education of our children. Further research is warranted to find alternative methods of physical activity in the classroom setting, such as stability balls, to serve as methods to improve BMI and other health parameters and potentially improve future health.

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