Journal of Physical Education and Sport ® (JPES), Vol 20 (Supplement issue 1), Art 61 pp 425 – 429, 2020
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

The effects of integrating physical activity into mathematic lessons on mathematic test performance, body mass index and short term memory among 10 year old children

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Published online: February 29, 2020
(Accepted for publication: January 20, 2020)
DOI:10.7752/jpes.2020.s1061

Abstract:
The benefits of physical activity on academic achievements and cognitive performances have attracted a growing interest among researchers and practitioners. Identifying approaches that may foster its effects is crucial. This study examined the effect of integrating physical activity during mathematic lesson on mathematic test performances, short term memory and anthropometric variables using a quasi-experimental design. Among school students.Fifty six primary school students aged 10 years old were recruited and randomly assigned into two groups (n = 28 per group), a physical activity and a control groups. Physical activity was delivered during mathematic lesson for 60 minutes per week, 2 sessions, and 30 minutes per session for 7 weeks. Physical activities include jumping, running and walking. The nonphysical activity group was taught via traditional teaching method. The results of mixed factorial ANOVA (2 groups x 2 testing sessions) revealed no significant interactions in any of the measured parameters. However, the percent increase of digit span test in physical activity group was higher (+34.60%) than nonphysical activity group (+21.09%). Furthermore, the percentage decrease in BMI physical activity group was larger (-1.62%) compared to the decreased in BMI observed in nonphysical activity group (-1.30%). The percent increase of mathematic test score was higher in non-physical activity group (+23.29%) compared to the physical activity group (+14.28%). Physical activity may contribute to academic performance via cognitive functions mechanism following an appropriate types and intensity of activities.
Key Words: Academic performance, Physical activity, Cognitive functions, Short term memory, Body mass index

Introduction

Academic achievement has always been an important aspect among school students life. Inherently, students spend a lot of times studying, doing homework and attending extra tuition (Singh *et al.*, 2012). In a survey conducted among 500 parents by The Straits Times and a research company Nexus Link, they found that seven in 10 parents enrolled their children in some extra classes for the purpose of increasing academic performances (Davie, 2015). Heavy emphasis on examination, unfortunately, has been shown to compromise participation in physical activity, especially sports and exercise (Hashim, Golok, &Rosmatunisah, 2011), leading to an increase in physical inactivity in this population.

The decline in physical activity participation among children and adolescents is alarming. For instance, in a study was conducted byZalilah, Khor, Mirnalini, Norimah, and Ang(2006) among 301 males and 317 females subjects using the instrument of physical activity 3-day activity record and the result shows that the time spent by the children and adolescents in moderate to vigorous physical activity was mere 2.8 minutes per day including housework and other movements (Zalilah*et al*., 2006). In fact, recent World Health Organization's report indicates that the prevalence of physical inactivity among school aged children and adolescent in Malaysia is the highest in South East Asia countries.

It has been suggested that regular physical activity could positively influence students' academic performance. For instance, Grissom (2005) found positive associations between levels of fitness and academic performance among students of grades 5, 7, and 9 covering about 884,715 students in California. Similarly, Chomitz, Slining, McGowan, Mitchell, Dawson and Hacker (2008) demonstrated a significant positive relationship between fitness and achievement in Mathematics and in English among urban public school children. In an experimental study, Donnelly et al. (2009) conducteda 3-year cluster randomized, controlled trial of 24 elementary schools among grade 2 and 3 students to compare changes in fitness and fatness with changes in academic achievement. The experimental group received 90min/week of moderate to vigorous physical activity delivered during the academic lessons. The results from that study show that schools with greater than 75 min of physical activity showed significantly Significant improvements in academic achievement from baseline to three years were observed in the group receiving physical activity during lesson compared to the control schools for the composite, reading, math, and spelling scores (Donnelly et al., 2009).

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It has been suggested that the movement of skeletal muscle during physical activity increase blood flow in the brain, increase cardiac output, vasodilation that can increase blood flow to the tissue and improve brain function in the brain that can lead to increased academic achievement(Morgan, Corrigan and Baune, 2015).More importantly, positive academic outcomes associated with engagement in physical activity may counter the negative view that it compromises students' academic performance.

The studies investigating the effect of physical activity on academic performances however have also yielded contradictory results. For instance, a recent large sample experimental studies involving 1129 fifth-grade children (age: 10.2 ± 0.3 years old) revealed no significant effect of the intervention on any academic performance measure in the primary analyses. The result revealed a favorable intervention effect for those who performed the poorest at baseline for numeracy. Similarly, a study conducted by Reed et al. (2010) also revealed no significant effect of physical activity intervention on math test performance in 3rd grades children.

These inconsistent findings certainly warrant further studies in these areas. Therefore, the purpose of this study was to determine the effects of physical activity intervention delivered during math lesson on mathematic test performance, short term memory and body mass index among 10 year olds students.

Materials and methods

This study was a pre-post quasi experimental design which was designed to examine the effects of 7 weeks of physical activity on academic achievement, body mass index and cognitive performances in primary school students.

Participants

Fifty six primary students aged 10 years old were recruited and being assigned into two groups, with twenty eight participants per group (n=28). The inclusion criteria for participants were male and females and absence of any medical problem. The exclusion criteria were participants who attend mathematic tuition outside school session and presence of any medical problem such as asthma, muscle weakness and injuries.

The sample size was calculated using G Power 3.0.10 (Faul *et al.*, 2009). The power of the study was set at 80% with 95% confident interval and the effect size of F at 0.25. With two groups and two repetitions, a minimum of 60 participants was required to achieve the specific power. To account for 20% drop-out rate, 5 participants were added to each group. Therefore, 35 participants per group were recruited (total 70).

Instruments and Procedures

*Anthropometric Instruments.*Anthropometric parameters such as body height and body weight were measured during pre and post-test. Standing height was measured using a portable stadiometer (Seca 220, Germany). The participants were asked to stand straight on the stadiometer with shoeless. Researcher was standing in front of the participants to get a correct value of the height, in centimetre (cm). Then, participants were weighed wearing sport school uniform without shoes by using a body composition analyser (Tanita, model TBF – 410). Body weight was recorded in kilogram (kg). Participants were required to wear sport school uniform attire and shoeless during these measurements. The measurement was repeated 2 times and the average was recorded. Body mass index (BMI) was calculated as weight (kg)/height (m).

*Mathematic test.*Academic achievement for mathematic was measured using researcher developed math test. 12 questions representing a total of 35 marks were prepared by researcher based on the Ministry of education endorsed Mathematic textbook of standard four. Easy and moderate level of questions were chosen and the appropriateness of the sample questions was checked by a senior Mathematic teacher with 25 years of experience in teaching primary school mathematics.

Participants were required to answer the questions in 20 minutes and write the answer in the paper given with pencil and without calculator. Participants who answer a question correctly with correct solution were given full marks (35 marks for 12 questions). If the answer was wrong but the solution wrote by participants were correct, one mark was given. The test was based on twelve topics of standard four listed below:

1. Numbers up to 100000
2. Add around 100000
3. Minus around 100000
4. Multiple up to 100000
5. Divide up to 100000
6. Combination operation
7. Fraction
8. Decimal
9. Percentage
10. Money up to 100000
11. Time
12. Length

Digit Span Subtest Memory was measured using Digit Span Subtest (DS). The DS is a Performance subtest from the Wechsler Memory Scale-Third Edition (WMS-III) which is an individually administered battery of learning, memory, and working memory measures. This task consists of 17 sets of number sequence forward and backward. The sequence is represented by two to 9 digit numbers. Each sequence appearing on the screen for 3

seconds and the students write the number in the same sequence on a provided sheet. Sequences of increasing length were administered in both conditions.For each trial, score 1 point was given if the student wrote the exact sequence. Score 0 points if the student does not write every digit or makes an error in the sequence. Sum of Forward Total Score and Backward Total Score was used for total score.

Procedure - Approval for the study was obtained from the Human Research Ethics Committee of Universiti Sains Malaysia and the principals of the participating schools. On the first visit to the school, students were briefed by the researcher regarding the test which consist of 3 sessions of familiarization, pre and post-test (anthropometry measurement, mathematic test, Digit Span Test). They were provided with detail information regarding the study and also the parental informed consent forms.Those who return consent forms signed by their parents or legal guardians were then screened for eligibility based on the inclusion and exclusion criteria. Prior to pre-test, participants were measured on their anthropometric profile, mathematic ability and short term memory following the procedures highlighted above.

*Physical activity intervention.*Participants in physical activity group engaged in physical activity during math lesson. The activity comprises 60 min/week of moderate physically active academic lessons. For example, participants were instructed to step forward, step backward and slow jump for the mathematic problems involving addition, subtraction, and multiplication respectively. The intervention was delivered across 7 weeks from August to October 2017. The lessons link physical activity with specific academic learning objectives for mathematic study following the standard Year 4 textbook. To enhance student understanding of the activity, afamiliarization session was conducted during which participants were taught to understand the required movement (e.g., step forward for addition, step backward for subtraction and slow jump for multiplication).

All participants in thephysical activity group performed the task 60 minutes per week, 2 sessions, and 30 minutes per session for 7 weeks. Participants involved activities such as jumping, running and walking. One of these activities was selected by the researcher for each physical activity sessions. The participants who did not attend at least 80% (5 times) of the classes were withdrawn from the study. The researcher monitored the adherence to experimental protocol. The control group were taught via traditional classroom method of similar lesson frequency and duration.

Statistical Analysis - Data were analysed using the statistical software in the Statistical Package for Social Science (SPSS) Version 22.0. All data were expressed as means and standard deviation (SD). Mixed factorial ANOVA was performed to determine the significance of the difference between and within groups. Statistical significance was accepted at $p<0.05$.

Results

The present study was designed to determine whether physical activity, integrated during math lesson, affects math test performances, short term memory, and body mass index among 10 years old primary school students. These variables were measured at pre- and post-intervention.

Descriptive statistics of the primary variables are presented in Table 1. The results of Mixed Factorial ANOVA are presented in Table 2.

Table 1. Descriptive statistics of the primary variables

	Group	Mean	Std. Deviation	Std. Error Mean	Pre to Post Percentage Mean Change
Pre Height	Physical activity	1.3354	.04520	.00923	
	Nonphysical activity	1.3364	.04182	.00836	
Post Height	Physical activity	1.3467	.05036	.01028	0.74
	Nonphysical activity	1.3512	.04816	.00963	1.49
Pre Weight	Physical activity	31.0542	5.82207	1.18843	
	Nonphysical activity	29.0440	6.66590	1.33318	
Post Weight	Physical activity	31.0792	5.96606	1.21782	0.06
	Nonphysical activity	29.3440	6.83600	1.36720	1.02
Pre BMI	Physical activity	17.3658	2.86096	.58399	
	Nonphysical activity	16.2080	3.23180	.64636	
Post BMI	Physical activity	17.0808	2.84890	.58153	1.62
	Nonphysical activity	15.9913	3.13524	.62705	1.30
Pre Math Score	Physical activity	14.958	6.3055	1.2871	
	Nonphysical activity	15.060	7.0509	1.4102	
Post Math Score	Physical activity	17.250	7.4147	1.5135	14,28
	Nonphysical activity	19.300	6.6599	1.3320	23.29
Pre Memory	Physical activity	9.08	3.175	.648	
	Nonphysical activity	9.84	2.688	.538	
Post Memory	Physical activity	12.88	3.248	.663	34.60
	Nonphysical activity	12.16	2.410	.482	21.09

As can be seen from Table 2, no significant interactions in any of the measured variables were obtained. However, as shown on Table 1, the pre-post percent change was higher in cognitive performances and BMI in the physical activity group. The percent increase of digit span test in physical activity group was higher (+34.60%) than nonphysical activity group (+21.09%). Furthermore, the percentage decrease in BMI physical activity group was larger (-1.62%) compared to the decreased in BMI observed in nonphysical activity group (-1.30%). The percent increase of mathematic test score was higher in non-physical activity group (+23.29%) compared to the physical activity group (+14.28%).

Table 2. Mixed ANOVA results comparing groups across testing sessions

Test of Within-Subjects	Type III Sum of Squares	df	Mean Square	F	Sig.
Mathematic test scores					
Time	281.155	1.000	281.155	21.805	0.000
Time*Group	26.155	1.000	26.155	2.028	0.160
Error (time)	696.289	54.000	12.894		
BMI					
Time	0.626	1.000	0.626	0.379	0.541
Time*Group	2.546	1.000	2.546	1.540	0.220
Error (time)	89.306	54.000	1.654		
Short term memory					
Time	230.809	1.000	230.809	31.717	0.000
Time*Group	24.809	1.000	24.809	3.409	0.070
Error (time)	392.968	54.000	7.277		

Discussion

The effects of participation in physical activity on academic performances and cognitive functions among school students. The present study examined the effect of physical activity intervention incorporated into math lesson compared to traditional teaching methods. The findings indicated no significant different between the groups receiving physical activity across testing session on any of the measured variables. Although the finding contradict our expectation, it is not an isolated findings. There are studies that have shown non-significant effects of physical activity on academic achievement and cognitive functions.

For instance, in a 7-month, school based physical activity intervention, Resaland et al (2016) found no different between physical activity and a control group on academic performance among 1129 fifth grade children. The researchers however, observed an effect of physical activity on academic performance for those performed poorest during baseline measure. This is not evidence in our study. In another study conducted by Reed et al (2010) indicated the similar nonsignificant effect of integrating physical activity into lesson delivery among 155 3rd grade students. No significant different was observed in math test performance at the end of the 3-months intervention.

While Resaland et al.and Reed et al.'s study employed a longer duration and higher exercise volume, our study employed a shorter duration and lower exercise volume. Even so, we believe that the nonsignificant findings are not attributed to these aspects. Instead, we believe that the novelty of the teaching methods, the intensity of the activity, and the structure of lesson may partly explain the findings.

Specifically, we observed a larger increase of math performance in the control condition (i.e., group receiving traditional lesson delivery). Firstly, integrating movement during learning is new to all of the subjects. Thus, topical mastery may be affected by this novel experience. Secondly, pedagogical limitation may also affect the results. Specifically, the total time students engaged in physical activity during the lesson are not determined. In this regard, the total time that each student involved in the prescribed physical activity may be lower than the stipulated time.

Intensity is an important factor linking physical activity and cognitive functions, and consequently academic performance. Davis et al (2011) conducted a study examining exercise dose-response among sedentary and overweight children aged 7 to 11 years old. They were randomized into 13 ± 1.6 weeks of an exercise program (20 or 40 min/day), or a control condition. The results revealed dose-response benefits of exercise on executive function and mathematics achievement. Specifically, higher intensity exercise provide greater benefits compared to the lower intensity and the control condition.

We also observe from the findings that the pattern of academicperformance was higher among students in the controlled condition. Although this specific pattern is difficult to be explained, academic performances is multifactorial. Student extra learning outside the classroom was not controlled and may confound the results. However, we do observe higher level of short term memory in the experimental groups.

Conclusion

From this study, it was found that physical activity did not provide a significant impact on academic achievement. However, positive patterns are observed for body mass index and short-term memory, relative to the control group. Future studies may address aspects such as exercise frequencies, duration and intensity as well

as other types of physical activity. Moreover, a wider outcome measures of cognitive and psychosocial aspects such as concentration, reaction time and enjoyment may also be considered to provide a comprehensive evaluation of its effectiveness.

Conflicts of interest

There is no conflict of interest involved.

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