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INTEGRATING PHYSICAL ACTIVITY IN MATHEMATICS LESSONS – A PILOT STUDY

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ABSTRACT

Introduction: *The aim of the study was to investigate the effect of teaching mathematics through physical activity tasks in the sixth grade. With an accelerometer we measured the amount and intensity of physical activity and the time of physical inactivity during school hours and, particularly, during mathematics lessons.*

Methods: *Twenty-two sixth graders from a Slovenian primary school participated in the study. The experimental group consisted of 16 students and the control group consisted of 6 students. Mathematics lessons were planned together with the mathematics teacher. This was then carried out in the experimental group. In the control group, the mathematics lessons remained unchanged. The intervention lasted for one week. For the duration of the experiment, students wore an accelerometer on their right hip during school hours.*

Results: *We found that the experimental group engaged in moderate to vigorous intensity physical activity for 7.8 minutes more during mathematics lessons ($P < 0.001$) than the control group. In addition, the experimental group was less physically inactive during math lessons for 6.7 minutes ($P = 0.001$) than the control group. Physical activity during school hours did not differ between groups ($P = 0.284$). Nevertheless, the experimental group spent slightly more time at moderate to vigorous intensity during school hours than the control group and was less physically inactive.*

Conclusion: *This study showed that integrating physical activity with mathematics in the academic classroom results in increased moderate to vigorous physical activity compared to a traditional classroom. Further research should be conducted to deter-*

mine how integrating physical activity with various school subjects affects daily physical activity in children and adolescents.

Keywords: *children, sixth grade, moderate to vigorous intensity, accelerometer*

VKLJUČEVANJE GIBALNE AKTIVNOSTI V URE MATEMATIKE - PILOTNA ŠTUDIJA

IZVLEČEK

Uvod: *Cilj raziskave je bil ugotoviti učinek vključevanja gibalne/športne aktivnosti v ure matematike na količino in intenzivnost gibalne/športne aktivnosti učencev med šolskim časom in v času ur matematike.*

Metode: *V raziskavo je bilo vključeno 22 šestošolcev iz slovenske osnove šole. V eksperimentalno skupino je bilo vključenih 16 učencev, v kontrolno pa 6. Z učiteljico matematike smo načrtovali ure matematike z gibanjem, ki jih je izvajala le v eksperimentalni skupini. Kontrolna skupina pa je imela ure matematike nespremenjeno, na klasičen način. Raziskava je trajala en teden in v tem obdobju so učenci v času šolskega pouka okoli pasu nosili pripet merilnik pospeška.*

Rezultati: *Ugotovili smo, da so bili učenci eksperimentalne skupine deležni za 7,8 minut več srednje do visoke intenzivnosti gibalne/športne aktivnosti v času ur matematike ($P < 0.001$) v primerjavi z učenci kontrolne skupine. Prav tako so bili učenci eksperimentalne skupine pri urah matematike za 6.7 minut manj gibalno neaktivni ($P = 0.001$) kot učenci kontrolne skupine. Gibalna/športna aktivnost v celotnem šolskem času pa se med skupinama ni razlikovala ($P = 0.284$). Kljub temu se je eksperimentalna skupina v šolskem času zadrževala nekoliko več časa v srednji do visoki intenzivnosti ter bila manj gibalno neaktivna kot kontrolna skupina.*

Zaključki: *Raziskava je pokazala, da z vključitvijo gibalne/športne aktivnosti v ure matematike lahko povečamo čas zadrževanja v srednji do visoki intenzivnosti gibalne/športne aktivnosti med urami matematike. V prihodnje bi bilo potrebno narediti več raziskav o tem, kako vpliva vključitev gibalne/športne aktivnosti v različne šolske predmete na količino in intenzivnost gibalne/športne aktivnosti otrok v šolskem času.*

Ključne besede: *učenci, šesti razred, srednja do visoka intenzivnost, merilniki pospeška*

INTRODUCTION

Today, children worldwide are not getting enough physical activity (PA) and are not meeting the minimum recommendations for moderate to vigorous physical activity (MVPA) (Institute of medicine, 2013; NASPE, 2019; Szabo-Reed, Willis, Lee, Hillman, Washburn & Donnelly, 2017; WHO, 2019). There is compelling evidence of the benefits of regular PA for a variety of health outcomes, from prevention of cardiovascular disease (Penedo & Dahn, 2005; Warburton, Nicol & Bredin, 2006), diabetes (Warburton et al., 2006), hypertension (Warburton et al., 2006), to various cancers (Penedo & Dahn, 2005). Physical activity has benefits only if done regularly and at an appropriate intensity. It is recommended that children engage in physical activity at MV intensity for at least 60 minutes each day (Institute of medicine, 2013; NASPE, 2019; Szabo-Reed et al., 2017; WHO, 2019). Children spend a large amount of time at school each day being physically inactive (Szabo-Reed et al., 2017). One of the ways to increase physical activity in school is to integrate it into school learning (Institute of medicine, 2013; Szabo-Reed et al., 2017).

All over the world there are various programs that combine physical activity tasks with academic learning, such as "Energizers" (Mahar, Murphy, Rowe, Golden, Shields & Raedeke, 2006), "I-CAN!" (Bartholomew, Golaszewski et al., 2018; Bartholomew, Jowers et al., 2018; Bartholomew, Jowers & Golaszewski, 2019), "Move for Thought" (Vazou, Saint-Maurice, Skrade & Welk, 2018; Vazou & Skrade, 2016), "Move-to-Improve" (Dunn, Venturanza, Walsh & Nonas, 2012), "Take10!" (Goh, Hannon, Webster, Podlog & Newton, 2016; Reilly, Buskist & Gross, 2012; Stewart, Dennison, Kohl & Doyle, 2004), "Activity Bursts in the Classroom for Fitness" (Katz et al., 2010), "Instant Recess" (Whitt-Glover, Ham & Yancey, 2011), "Bizzy Break" (Murtagh, Mulvihill & Markey, 2013), "ExCiTE" (Innerd, Azevedo & Batterham, 2019), "FUNtervals" (Ma, Mare & Gurd, 2014; Ma, Mare & Gurd, 2015), "Physical Activity across the Curriculum" (Donnelly et al., 2009, Donnelly et al., 2017; Donnelly & Lambourne, 2011; Mullender-Wijnsma, Hartman, De Greeff, Bosker, Doolaard & Visscher, 2015a; Szabo-Reed et al., 2017), and "Happy 10" (Liu et al., 2007).

To increase PA during school time among Slovenian children, various programs have been used, such as "Aktivna pot v šolo in iz nje – Pešbus" (Institute for spatial policies, 2020), "Aktiven šolski odmor" (Jurak et al., 2016), "Minuta za zdravje" (Jurak et al., 2016), "Dodatna ura športa v podaljšanem bivanju" (Subotić, 2012), and "Fit Slovenija" (Fit Slovenia, 2019). However, there are few studies that have integrated physical activity into non-physically-active lessons (Bratož, 2015; Cotič, Ivanič & Žakelj, 2010; Rabuza, 2010; Volk, 2015).

Other countries (Donnelly et al., 2009; Innerd et al., 2019; Kibbe et al., 2011; Martin & Murtagh, 2015; Norris, Van Steen, Direito & Stamatakis, 2020; Vetter, Orr, O'Dwyer & O'Connor, 2020) have investigated the impact of integrating physical activity into school lessons on the quantity and intensity of children's physical activity. Many of these studies included PA in mathematics (Innerd et al., 2019; Kibbe et al., 2011; Martin & Murtagh, 2015; Vetter et al., 2020) or languages lessons (Innerd et al., 2019; Kibbe

et al., 2011; Martin & Murtagh, 2015). They indicated that active learning in the classroom successfully increased the amount, duration, and intensity of PA. Active learning could increase children's PA for 2.8 to 7.7 minutes (Bartholomew, Golaszewski et al., 2018; Daly-Smith, Zwolinsky, McKenna, Tomporowski, Defeyter & Manley, 2018; Donnelly et al., 2009; Innerd et al., 2019; Institute of medicine, 2013; Kibbe et al., 2011; Martin & Murtagh, 2015; Norris et al., 2020; Szabo-Reed et al., 2017; Vazou et al., 2018; Vetter et al., 2020). Similar results were obtained in studies from Slovenia. Ajdovec (2017) investigated the effect of integrating PA into non-physically active lessons on physical inactivity; on the other hand, Ovčjak (2016) integrated PA into music lessons and assessed the amount and intensity of PA during these lessons.

Many of these studies were conducted with children from 1st to 4th grade. Global trends suggest that PA decreases even further as children get older (Cox, Schofield, Greasley & Kolt, 2006; WHO, 2019a). Therefore, we were interested in the amount and intensity of PA of older children.

METHODS

Participants

A total of 22 children (mean age: 11.41; 12 boys and 10 girls) from the sixth grade of a primary school in Slovenia were recruited. We explained all the details to the headmaster, the mathematics teacher and the parents. The study involved a mathematics teacher who taught both groups - the experimental and the control group. 16 children participated in the experimental group, 6 children formed the control group. The parents of the children gave their written consent before the study was conducted.

Intervention

The study was conducted in May 2019. The intervention lasted five school days, from Monday to Friday. During the intervention, children had four lessons of mathematics. One lesson lasted 45 minutes. The teacher integrated PA in mathematics lessons of the experimental group. In the control group, the mathematics lessons remained unchanged. The children from both groups had the same mathematics lessons content. The mathematics lessons were planned together with the mathematics teacher. The PA tasks were of moderate to vigorous intensity, but relatively easy to perform. For example:

- True-or-false questions: if the statements were true, students did 5 jumps, if they were false, they did 3 squats;
- Fit box: We wrote different PA tasks on slips of paper and then put them in a box. The teacher chose a student to answer the questions. If she/he answered

correctly, she/he got to take a slip out of the box. The student read the task on the slip and the whole class performed that task.

Instruments

PA was measured using accelerometers (ActiGraph wGT3W-BT, ActiGraph, LLC) worn on the children's right hips. Data were collected for one week (five days) during school hours. Children's out-of-school PA data were not collected for this study. At the beginning of the study, we demonstrated how to properly fasten the accelerometer around the children's waists.

Data analysis

Accelerometer data were analyzed using activity counts of 15-second epochs. All sequences of 20 minutes or more with consecutive zero counts were excluded from each individuals' records. To distinguish between physical activity phenotypes, we considered the thresholds proposed by Freedson, Pober & Janz (2005):

- Physical inactivity (PI): < 100 cpm,
- Low PA: 100–1262 cpm,
- Medium PA: 1263–4135 cpm,
- Vigorous PA: > 4135 cpm.

Data were organized using the Microsoft Excel program (Microsoft Corporation, Redmond, USA) and processed using the SPSS statistical package (IBM Corp., Armonk, NY, USA). Differences between groups in vigorous PA during mathematics lessons were analyzed using the Mann Whitney U test. This test was used because the data were not normally distributed. For the other intensity levels, the independent samples t-test was used. All statistical decisions were considered at $p < 0.05$.

RESULTS

From the accelerometer data, we calculated the average of each PA intensity phenotypes during mathematics lessons for both groups (Table 1). The results showed that there were differences between the groups in all phenotypes of intensity. During mathematics lessons the experimental group was more PA in MV ($p < 0.001$; ES = 2.37), V ($p = 0.002$; ES = 1.48), M ($p < 0.001$; ES = 2.38) and L ($p = 0.005$; ES = 1.50) intensity compared to the control group. In addition, the experimental group was also less PI ($p = 0.001$; ES = 2.08) during mathematics than the control group.

Table 1. Comparing the levels of PA and PI between groups in mathematics lessons

	EG (mean ± SD)	CG (mean ± SD)	P (ES)
PA (cpm)	281.0 ± 104.1	69.9 ± 35.2	< 0.001 (2.72)
PI (minutes)	33.5 ± 3.7	40.2 ± 2.6	0.001 (2.08)
L PA (minutes)	8.5 ± 2.9	4.3 ± 2.3	0.005 (1.50)
M PA (minutes)	11.0 ± 3.5	3.6 ± 2.66	< 0.001 (2.38)
V PA (minutes)	0.5 ± 0.4	0.1 ± 0.1	0.002 (1.48)
MV PA (minutes)	11.5 ± 3.7	3.7 ± 2.7	< 0.001 (2.37)

Legend: EG – experimental group, SD – standard deviation, CG – control group, P (ES) – effect size, PA – physical activity, PI – physical inactivity, V – vigorous, M – medium intensity, L – low intensity, MV – medium to vigorous intensity.

We also compared the levels of PA and PI between groups during school time (Table 2). The level of physical activity during school hours did not differ significantly between groups. Nevertheless, the experimental group spent slightly more time in MV intensity ($p = 0.284$) than the control group during the whole school period and was less PI ($p = 0.284$) than the control group. The data showed that the experimental group spent 10.62 minutes more in MVPA than the control group. We believe that this difference is due to the integration of PA into mathematics lessons. We calculated the average level of PA during school time without PA during math lessons and the difference between the groups was only 2.9 minutes in MVPA. We found that students from both groups reached minimum recommendations for physical activity while still in school.

Table 2. Comparing the levels of PA and PI between groups during total school time

	EG (mean ± SD)	CG (mean ± SD)	P (ES)
PA (cpm)	415.7 ± 130.1	430 ± 108.4	0.814
PI (minutes)	180.9 ± 19.9	191.5 ± 20.9	0.284
L PA (minutes)	51.7 ± 12.6	41.6 ± 14.7	0.125
M PA (minutes)	73.8 ± 18.4	61.0 ± 19.7	0.169
V PA (minutes)	5.3 ± 3.1	7.5 ± 2.1	0.128
MV PA (minutes)	79.1 ± 19.9	68.5 ± 20.9	0.284

Legend: EG – experimental group, SD – standard deviation, CG – control group, P (ES) – effect size, PA – physical activity, PI – physical inactivity, V – vigorous, M – medium intensity, L – low intensity MV – medium to vigorous intensity.

DISCUSSION

The purpose of this study was to investigate the effect of teaching mathematics through PA tasks on PA. Using an accelerometer, we measured PA and PI of sixth-grade children during mathematics lessons and during school time.

The data for PI during mathematics lessons showed that the control group was 74.4% of the mathematics lessons PI, while the experimental group was only 14.9% of the lessons PI. Vazou et al. (2018) also found differences between the groups. They integrated PA in the mathematics lessons of fourth-grade children. During the experimental lessons, they were 40.44% of the lessons PI, in contrast, during control time they were 42% PI. Martin and Murtagh's (2015) study showed similar results. Children were at 46.49% less PI during the English and mathematics than during regular lessons. Ovčjak (2016) measured the PI of Slovenian children during active music lessons. She found that in the experimental group 23.9% of lessons were PI and in the control group 62.9%. We can conclude that the other studies found smaller differences between the groups compared to our results. We think that this difference is due to the fact that the other studies included younger children than ours. It is generally believed that PA decreases with age, so this may lead to an increased PI (Calvert, Mahar, Flay & Turner, 2018; Volmut, Pišot & Šimunič, 2013; Webster, Russ, Vazou, Goh & Erwin, 2015).

In this study, the experimental group spent 25.56% of lessons in MVPA, the control group 8.22%. Other studies have reported similar results (Vazou et al., 2018; Martin & Murtagh, 2015; Mullender-Wijnsma et al., 2015a, Ovčjak, 2016). Martin and Murtagh (2015) found that children in the experimental group were in MVPA 23.5% of the active lessons. From ours and other studies, we can see that the integration of PA into mathematics lessons can improve primary school children's MVPA level and reduce

PI during mathematics lessons. It is also interesting to compare our results with those of Pušnik (2013). He measured the effective time parameters of physical education and the time children spent in MVPA. He found that children spent 13.22 minutes in MVPA during physical education. This is very close to our results where the experimental group spent 11.5 minutes in MVPA during mathematics lessons. We can assume that the integration of physical activity during mathematics lessons may be closer to MVPA intensity during physical education lessons. However, as we know, children perform complex motor tasks during physical education, while only performing simple motor tasks during experimental mathematics instruction.

We also measured PA and PI of sixth-grade children during school hours. We found that the extent of MVPA during school hours did not differ significantly between the groups. The experimental group spent 79.1 minutes in MVPA during all school time and 180.9 minutes PI, while the control group spent 68.47 minutes in MVPA and 191.5 minutes PI. Nevertheless, we observed a slight trend in the differences between the groups in MVPA. Other studies found significant differences between groups in MVPA (Bartholomew, Jowers et al., 2018; Calvert et al., 2018; Erwin, Abel, Beighle & Beets, 2011), but some of them found no differences in PI (Bartholomew, Jowers et al., 2018). Bartholomew et al. (2018) measured PA during school hours when students received 10-15 minutes of active lessons. The results of his study showed that children in experimenting schools took more steps and moved more in percentage points during the school week than students in control schools, but there were no statistically differences in sedentary behavior. Another study (Riley, Lubans, Holmes & Morgan, 2016) reported that the experimental group engaged in PA significantly more and tended to spend more time in MVPA during school hours compared to the control group. Intervention effects were also found for sedentary behavior during school hours. The control group was PI 67.8% of school time, while the experimental group was PI 62.6% of school time.

Innerd et al. (2019) measured PA at baseline, at the end of the intervention, and 4 weeks after the intervention. The difference in average daily MVPA (experimental-control) was 2.8 minutes/day at 8 weeks and 7.0 minutes/day at follow-up. In addition, Donnelly et al. (2009) observed PA during the spring semester in each of the 3 intervention years. Children who participated in physically active classes had significantly higher levels of PA during the school day, on weekends, and also on weekdays compared to children in control schools. This could be explained by a change in children's attitude and their belief that they can be anywhere and in almost any situation PA. After this finding, we could predict that our intervention was too short to obtain reliable data on how the integration of PA into mathematics lessons affects the level of MVPA during school time.

This study also has some other limitations. One of them is the small sample size. The participants were only from the sixth grade, and we only included PA in the mathematics lessons. In the future, more research should be done on how the integration of PA into different school subjects affects children and adolescents' daily PA. Unfortunately, our study could not examine how the inclusion of PA tasks affected children's

academic performance - particularly in mathematics - cognitive ability, or on-task behavior, because the intervention program lasted only five school days, during which students in the experimental and control groups received only four hours of mathematics instruction. A larger effect would not necessarily have been a reflection of the intervention program only, but also of a higher motivation and concentration of students in learning mathematics. In addition, we should not neglect the fact that students learn at home (e.g., write math homework) and that teachers are in all likelihood better prepared for the intervention program when they teach math. Teachers are not used to on this type of teaching and therefore take more time to prepare than usual. We need to be careful when comparing our study with others as they may have used different methods to measure and analyze the data.

CONCLUSIONS

Finally, this study showed that integrating PA with mathematics in the academic classroom resulted in increased MVPA during lessons. In addition, we found that students in both groups achieved the minimum recommendations of PA while still on school time. Previous research has shown that physically active classes also improve academic performance (Ma et al., 2015; Mullender-Wijnsma et al., 2015a; Mullender-Wijnsma, 2015b; Mullender-Wijnsma, 2016; Vazou & Skrade, 2016). This should be an additional encouragement for teachers to integrate physical activity into their classes.

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