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The Relationship between Physical Activity and Academic Achievement in Primary School Pupils with Hearing Impairment

Irina Kliziene[1ABCDE] **and Gintaute Sinkeviciene**[1ABCDE]

[1]Kaunas University of Technology

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Corresponding Author: Irina Kliziene, e-mail: irina.kliziene@ktu.lt
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Abstract

Background. Hearing impairment is one of the most frequently occurring diseases in children, both congenital and acquired. It affects approximately 1 to 3 children in every 1000 (Seifert et al., 2005).

Objectives. This study aimed to reveal the impact of physical activity on the mathematics achievement of primary school pupils with hearing impairments.

Materials and methods. The Children's Physical Activity Questionnaire (Corder et al., 2009) was used, which is based on the Children's Leisure Activities Study Survey questionnaire, which includes activities explicit to little children, such as "playing in a playhouse". The Mathematics Progress Monitoring Test (MPMT) (Kliziene et al., 2024) was adapted for pupils with hearing impairment. The MPMT was used to assess the mathematics achievement of the students who took part in the study. They were designed to evaluate each pupil's achievement level, which, according to the general curriculum, was divided into unsatisfactory, satisfactory, basic, and advanced. The mathematics achievement of pupils with hearing impairment was assessed in four areas of the mathematics curriculum.

Results. The posttest results of first-grade primary school pupils with hearing impairments (158.95 MET, min/week) were analyzed to compare average physical activity with the pretest results (125.61 MET, min/week), during physical education lessons. Walking to school (20.39 MET, min/week) and cycling to school (16.85 MET, min/week) showed statistically significant differences (between types of physical activity) in the pretest and posttest according to MET $p < 0.05$. PA helped pupils with hearing impairment to achieve basic results (pretest (5.81 (3.25) posttest (16.84 (2.98); $p = 0.000$) and advanced results (pretest (0.81 (0.53) posttest (4.18 (0.47); $p = 0.002$).

Conclusions. According to the findings, it was established that properly interpreted and appropriately applied physical activity for primary school pupils with hearing impairment led to statistically significant changes in dependent variables: an increase in pupils' physical activity and academic achievement. Marked changes were observed in mathematics tasks that required higher-level thinking skills, knowledge, and understanding; distribution of mathematics learning achievement by content such as natural and integer numbers, patterns and relationships, geometry and measurements, data, and statistical probabilities. Higher levels of physical activity resulted in achievement levels changing from satisfactory to basic and advanced.

Keywords: physical activity, achievement in mathematics, learners with hearing impairment.

Introduction

Hearing impairment is one of the most frequently occurring diseases in children, both congenital and acquired. It affects approximately 1 to 3 children in every 1000 (Seifert et al., 2005). Hearing impairment is an invisible disability, which can be invisible or overlooked by the teacher, or sometimes the child may deliberately hide it. The teacher may assume that everything is fine, even if the pupil has difficulty hearing (Powell et al., 2014). This can lead to a strange situation: a child has skills and abilities but cannot use them because he or she cannot hear instructions. This can lead to pupils achieving poorly (Punch, Hyde, 2011). Even if hearing conditions are optimal during lessons, noisy breaks or lunch breaks can cause communication problems.

Compared to hearing children, pupils with hearing impairment have been found to have lower motor skills and physical fitness, which can have a negative impact on their engagement in physical activity (PA) and active lifestyles (Martin et al., 2013).

Therefore, the research questions were formulated as follows: What is the physical activity level of primary school pupils with hearing impairments? How does physical activity contribute to the achievement of primary school pupils with hearing impairments in mathematics?

The aim of the research: is to reveal the impact of physical activity on the mathematics achievement of primary school pupils with hearing impairments.

There are few studies that have looked at the engagement of deaf pupils with hearing impairment of hearing pupils in PA. This knowledge will be of great importance to policymakers and researchers to implement effective disease prevention.

Physical Activity of Primary School Pupils with Hearing Impairment. Physical activity (PA) is important for the development of children with hearing impairment (Xu et al., 2020). A meta-analysis found that physically active school-age children with hearing impairment have a better quality of life than sedentary learners (Kitterick et al., 2015). The World Health Organisation (WHO) has recommended that children and adolescents with and without disabilities should engage in at least 60 minutes of physical activity every day (World Health Organization, 2020). However, it is established, that only 20% of boys, girls, and adolescents with hearing impairment have been found to meet the World Health Organisation recommendation to engage in 60 minutes of physical activity daily (Li et al., 2019). Martínez et al. (2022) study found that PA was higher during school recess than during physical educational lessons among hearing-impairment pupils. Established, that facilitating the attendance of pupils with hearing impairment in physical education lessons requires strategies that address different aspects of the same lesson. Successful strategies were actions that had an educational purpose, achieved the pupil's functionality, and considered the pupil's qualities, needs, and capabilities (Kashuba et al., 2020).

Physical Activity and Mathematics Achievement for Pupils with Hearing Impairment. Research suggests a positive relationship between physical activity and academic achievement for primary school pupils, including those with hearing impairments. Studies have found that sports participation can significantly improve academic performance in hearing-impaired children (Ahmed et al., 2020). For students with hearing impairments, motivation to engage in physical education is positively correlated with learning outcomes (Nugraha, et al., 2019).

Research on the use of physical activity to increase mathematics learning among students with hearing impairments has covered different aspects. Overall, these research studies emphasize the importance of integrating physical activity to improve the mathematics learning experience of pupils with hearing impairments, their overall engagement in the learning process, and a particular focus on improving physical abilities and increasing physical activity. However, there is not much research on this in the field of special education.

Materials and Methods

Participants

All First-Grade students with hearing impairment who were studying in Lithuanian deaf and hard-of-hearing education centers participated in the experiment. In 2022–2023, there were 13 pupils in the first grade in specialised deaf education institutions in Lithuania. Another criterion that was applied to the subjects was that students have been studying according to the general education program. Two pupils out of the selected 13 followed individualized education programs; therefore, only 11 students participated in this study (n = 11, including 6 boys and 5 girls).

The Evaluation of Physical Activity

The Children's Physical Activity Questionnaire (Corder et al., 2009) was utilized, which is based on the Children's Leisure Activities Study Survey (CLASS) questionnaire, which includes activities explicit to little children, such as "playing in a playhouse." The original intent of the proxy-reported CLASS questionnaire for 6–9-year-olds was to evaluate the type, recurrence, and intensity of physical activity over a standard week (Corder et al., 2009).

Mathematics Progress Monitoring Test

The Mathematics Progress Monitoring Test (MPMT) (Kliziene et al., 2024) was adapted for pupils with hearing impairment.

The MPMT was used to assess the mathematics achievement of the students who took part in the study. They were designed to assess each pupil's achievement level, which, according to the general curriculum, was divided into unsatisfactory, satisfactory, basic and advanced. The mathematics achievement of pupils with hearing impairment was assessed in four areas of the mathematics curriculum (General Curriculum Framework for Pre-primary, Primary and Secondary education (Order No V-1269 of the Minister of Education, Science and Sport of 24 August 2022; Kliziene et al., 2024) (Table 1):

Based on the test matrix, the mathematics content, the cognitive ability content groups and the pupils' levels of achievement in each area of the study, a maximum score was calculated to assess each pupil's achievement in a specific area of MPMT. To ensure equal evaluation of each pupil's MPMT results according to the fields of activity, MPMT evaluation instructions were used, and the limits of pupils' achievement levels were defined based on the MPMT characteristics (unsatisfactory, satisfactory, basic, advanced).

As defined in the MPMT profile, the level of achievement at the advanced level is 26-33 standard points on MPMT tasks; at the basic level, 12-25 standard points; at the satisfactory level, 5-11 standard points; and at the unsatisfactory level, 0-4 standard points (Kliziene et al., 2024).

Procedure

This study used a pretest and posttest methodology. Pupils with hearing impairments were assessed over a period of three months. A physical activity program was developed and a model of educational factors promoting physical activity among children was constructed.

Methodological materials for the physical activity program were also developed (Kliziene et al., 2021; Corder et al., 2009). The methodology was based on dynamic exercises, intensive repetition of motor skills, differentiation, reduction of the number of sitting and standing places, and

Table 1. Mathematics Curriculum content

Content of teaching(s)	
Natural and integer numbers	Numbers from 0 to 100. Addition and subtraction. Can read and write natural numbers up to 100, compare them, add and subtract two-digit numbers, perform addition and subtraction operations and solve simple real-world problems Financial calculations. Can analyse situations and solve problems that ask them to compare the prices of two goods (more expensive, less expensive), find the total price of goods in euros, and cents (within the euro limit), compare how much money has changed and what can be bought with the money available.
Patterns and relationships	Can use drawings, words and symbols to represent algorithms, and can represent a sequence of commands in a flow diagram.
Geometry and measurements	Measurement scales and units. Can be expressed as a number of length units. Can carry out a variety of practical tasks to get a feel for the mass of objects in the immediate environment that are or are not suitable for describing a unit of measurement. Figures. Can identify and correctly name simple geometric planes and figures; knows their names; apply existing knowledge of geometric planes and figures; can solve simple problems
Data and statistical probabilities	understands how data is presented, knows how to collect it, can read the information in a bar chart and can plot it on a graph based on data from the condition.
Cognitive ability groups	
Mathematical knowledge	The pupil is able to understand the concepts and perform standard mathematical procedures based on them.
Understanding	The learner is able to correctly understand and use the terms of the problems to solve the problems.
Applying mathematics and higher-thinking skills	The learner is able to solve more advanced problems, which are more difficult problems that are more procedural and have several possible strategies; the learner is able to choose and apply a strategy to solve the problem correctly.

Table 2. Physical activity program prepared according to the DIDSPA model for pupils with hearing impairments

	DIDSPA	Topic	Areas of Activity
Dynamic exercise	Aerobic capacity and/or muscle strength training. Physical activity can be any movement that improves physical well-being. Physical activity that provides more energy or endurance is usually referred to as aerobic activity.	Long jump-rope. Activity games. The long jump test to test the explosive power of children's leg muscles	Movement skills Movement skills Sports units (athletics)
Intensive repetition of motor skills	Reducing/eliminating queues so that children do not have to wait for their turn; small team games or group activities, e.g., 3 against 3 (this increases the number of times children can practice/apply their skills, – this helps to prevent children from being left on the sidelines or excluded from the game/activity); and increasing the amount of equipment available to children and/or increasing the number of stations.	Muscle stretching. Attempt to keep balance. Outdoor activity. Activity games. Jumping on two feet. Shuttle running 3 × 10 m.	Unconventional physical activity Sports units (athletics)
Differentiation	All children should be given tasks appropriate to their physical, emotional, and social situation that encourage them to participate actively in the learning process. Teachers should ensure that they are familiar with the space, tasks, equipment, and structure for the dynamic differentiation of activities.	Spider and turn. Animal aerobics. Children's Yoga.	Unconventional physical activity
Reduction of the number of sitting and standing places / Physical activity distribution in the classroom	When a teacher provides feedback questions to pupils, they do not need to stop the whole class, but can simply focus on a group of pupils or an individual child and pause their work. Engage children in the activity promptly, at the beginning of the exercise, by asking short questions and providing feedback. Ensure that equipment is ready, adjusted, and available at the beginning of and during the exercise.	Long jump-rope. The long jump test to test explosive power of children's leg muscles. Shuttle running 3 × 10 m.	

the model of physical activity distribution in the classroom (DIDSPA) (Powel et al., 2016) (Table 2).

Research Ethics

On February 6, 2023, the researchers received approval to conduct the investigation in accordance with protocol No. M4-2023-03. The heads of the educational institutions participating in the study and the parents of the participating students were informed about the purpose and course of the study. They were presented with the informed consent forms approved by the KTU Scientific Research Ethics Commission, in which all detailed information was included. The most important ethical principle of this study was to ensure the confidentiality of the participating pupils; therefore, no personal data of the students are presented in the study, and full pseudonymization of personal data is ensured.

Statistical Analysis

Descriptive statistics were reported for all measured variables as mean ±SD. The effect size of the Mann–Whitney U test was calculated using the equation $r = Z/\sqrt{N}$, in which Z is the z-score and N is the total number of the sample (small: 0.1; medium: 0.3; large: 0.5). Statistical significance was defined as $p \leq 0.05$ for all analyses. Analyses were conducted using SPSS 23 software (SPSS inc., Chicago, IL, USA).

Results

Physical Activity of Primary School Pupils with Hearing Impairment

Table 3 presents the results of the PA of first-grade primary school pupils with hearing impairments (pretest/posttest).

Table 3. Physical activity of primary school pupils with hearing impairment

Type of physical activity	MET	1 day/min	Days per week	MET, min/week
pretest				
Physical Education lesson	3.5	30	3	125.61
Cycling to school	4	0.57	2	12.67
Walking to school	3.3	0.70	3	13.27
Sport groups (mean physical activity)	6	60	1	921.08
On average for one first grade pupil with hearing impairment				1077.63*
posttest				
Physical Education lesson	3.5	30	3	158.95
Cycling to school	4	0.57	2	16.85
Walking to school	3.3	0.70	3	20.39
Sport groups (mean physical activity)	6	60	1	1105.93
On average for one first grade pupil with hearing impairment				1302.12*#

*– $p < 0.05$ (according to the Mann-Whitney U test) between types of physical activity; #– $p < 0.05$ between pretest and posttest

Analysing the physical activity pretest results of the pupils with hearing impairment, it turned out that the first grade (125.61MET, min/week) were physically active during physical education lessons and sports groups (921.08 MET, min/week). Types of physical activity, such as cycling to school (12.67 MET, min/week), analysis according to MET; and walking to school (13.27 MET, min/week) – were no differences between these physical activity types.

The posttest results of first-grade primary school pupils with hearing impairments (158.95 MET, min/week) were to analyze average physical activity compared to the pretest results (125.61 MET, min/week), during physical education lessons. Walking to school (20.39 MET, min/week) and cycling to school (16.85 MET, min/week), showed that there were statistically significant differences (between types of physical activity) in pretest and posttest according to MET $p<0.05$. A statistically significant difference was found during the analysis of the average MET pretest (1077.63MET, min/week) in comparison with the posttest (1302.12MET, min/week, $p<0.05$; Table 3). We showed a statistically significant difference (according to the Mann-Whitney U test) between pretest and posttest groups($p<0.05$).

Mathematics Achievement for Pupils with Hearing Impairment

Table 4 presents the results of the descriptive data of first-grade primary school pupils with hearing impairments by learning needs and difficulties in mathematics before and after PA (pretest/posttest).

We found that increased PA for hearing-impaired pupils showed a statistically significant increase in natural and integer numbers (pretest 10.05 (2.98), posttest 15.86 (1.52) ($p = 0.009$); Patterns and relationships: (pretest 3.21 (1.64), posttest 0.79 (0.88) ($p = 0.041$); Geometry and measurements: (pretest 1.58 (1.91), posttest 6.78 (1.16) ($p = 0.021$); Data and statistical probabilities (pretest 0.15 (0.84), posttest 1.99 (1.81) ($p = 0.030$) (Table 4).

Table 5 presents the distribution of pupils with hearing impairment in the at pretest and posttest by areas of cognitive ability. We found that for pretest results of mathematical knowledge engaging in PA for pupils with hearing impairment showed a statistically significant increase in mathematical knowledge – pretest 7.83 (1.14), posttest 11.95 (0.91) ($p = 0.048$). There was a statistically significant increase in understanding – pretest 6.58 (3.69), posttest 9.99 (2.08) ($p = 0.029$) and applying mathematics and higher thinking skills – pretest 0.51 (0.69), posttest 6.91 (0.86) ($p = 0.008$) (Table 5).

An analysis of the results of the Mathematics Achievements of Pupils with Hearing Impairments pretest (7.86 (1.48)) and posttest (5.24 (0.00)) Satisfactory level were not statistically different $p = 0.073$. As can be seen from the results, PA helped pupils with hearing impairment to achieve basic results (pretest (5.81 (3.25) posttest (16.84 (2.98); $p = 0.000$) and advanced results (pretest (0.81 (0.53) posttest (4.18 (0.47); $p = 0.002$) (Table 6).

Discussion

Our research was based on the premise that properly applied physical activity can improve both physical activity

Table 4. Distribution of Mathematics Learning Achievement by Content of Primary School Pupils with Hearing Impairment

Test	Pretest	Posttest	p-level	Observed power	Effect size
Natural and integer numbers	10.05 ± 2.98	15.86 ± 1.52	0.009	1.000	0.94
Patterns and relationships	3.21 ± 1.64	0.79 ± 0.88	0.041	0.691	0.79
Geometry and measurements	1.58± 1.91	6.78 ± 1.16	0.021	0.933	0.91
Data and statistical probabilities	0.15 ± 0.84	1.99 ± 1.81	0.030	0.901	0.77

Mathematical learning achievements: significant values are highlighted in bold. Effect size for non-parametric test: r (small: 0.1; medium: 0.3; large: 0.5) for group differences.

Table 5. Distribution of Mathematics Learning Achievement by Areas of Cognitive Abilities of Primary School Students with Hearing Impairment

Areas of Cognitive Abilities	Pretest	Posttest	p-level	Observed power	Effect size
Mathematical knowledge	7.83 ± 1.14	11.95 ± 0.91	0.048	0.764	0.68
Understanding	6.58 ± 3.69	9.99 ± 2.08	0.029	0.825	0.81
Applying mathematics and higher- thinking skills	0.51 ± 0.69	6.91 ± 0.86	0.008	1.000	0.95

Cognitive ability: significant values are highlighted in bold. Effect size for non-parametric test: r (small: 0.1; medium: 0.3; large: 0.5) for group differences.

Table 6. Levels of Mathematics Achievements of Pupils with Hearing Impairments

Level	Pretest	Posttest	p-level	Observed power	Effect size
Satisfactory	7.86 ± 1.48	5.24 ± 0.00	0.073	0.394	-
Basic	5.81 ± 3.25	16.84 ± 2.98	0.000	1.000	0.99
Advance	0.81 ± 0.53	4.18 ± 0.47	0.002	1.000	0.98

Effect size for non-parametric test: r (small: 0.1; medium: 0.3; large: 0.5) for group differences.

levels and academic performance and is particularly beneficial for students with hearing impairments.

After assessing the distribution of mathematics achievements according to the content of the curriculum, it was found that satisfactory and basic levels of mathematics achievement prevailed. Before the study, students performed poorly on tasks that required higher-level thinking skills. After the intervention, which used methods to encourage physical activity, the level of student achievement changed from satisfactory to basic and advanced, and from basic to higher. Significant changes were observed in mathematics tasks that required higher-level thinking skills. The results of our study showed that the promotion of physical activity led to a statistically significant increase in the distribution of mathematics achievement according to the content of the curriculum: natural and healthy numbers, patterns and relationships; geometry and measurement; data and statistical probability. Achmed et al, (2020) showed that there is a positive correlation between participation in sports activities and academic achievement among children with hearing impairment. Have et al. (2018) conducted a randomized controlled trial showing improved math achievement in elementary school children participating in a 9-month PA intervention. Relay et al (2016) found that integrating physical activity into subjects such as mathematics is a real opportunity for teachers to increase physical activity levels in schools without compromising academic performance and while improving pupils' task performance. Primary school teachers should be encouraged to incorporate movement-based learning into the overall curriculum.

Conclusion

It is established that properly interpreted and appropriately applied physical activity for primary school pupils with hearing impairment resulted in statistically significant changes in dependent variables: an increase in pupils' physical activity and academic achievement. Significant changes were observed in mathematics tasks that required higher-level thinking skills, knowledge, and understanding; distribution of mathematics learning achievement by content such us: natural and integer numbers, patterns and relationships, geometry and measurements, data and statistical probabilities. With higher levels of physical activity, achievement levels changed from satisfactory to basic and advanced.

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Взаємозв'язок між фізичною активністю та академічною успішністю учнів початкової школи з порушеннями слуху

Ірина Клізене[1ABCDE], Гінтауте Сінкевичене[1ABCDE]

[1]Каунаський технологічний університет

Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 6 табл., 19 джерел.

Історія питання. Порушення слуху є одним із найпоширеніших захворювань у дітей, що мають як вроджений, так і набутий характер. Від зазначеної хвороби страждає приблизно від 1 до 3 дітей із кожної тисячі (Seifert et al., 2005).

Мета дослідження. Мета цього дослідження полягала у виявленні впливу фізичної активності на успішність з математики учнів початкової школи з порушеннями слуху.

Матеріали та методи. У дослідженні застосовано опитувальник з визначення рівня фізичної активності дітей "Children's Physical Activity Questionnaire" (Corder et al., 2009), який базується на опитувальнику з дослідження дозвілля дітей "Children's Leisure Activities Study Survey" і включає види активності, що є характерними для маленьких дітей, як-от «гра в ігровому будиночку». Для учнів з порушеннями слуху було адаптовано тест з моніторингу прогресу з математики "Mathematics Progress Monitoring Test" (MPMT) (Kliziene et al., 2024). MPMT використовувався для оцінки навчальних математичних досягнень учнів, які брали участь у дослідженні. Тести були розроблені для визначення рівня навчальних досягнень кожного учня, який відповідно до загальної навчальної програми розподілявся на незадовільний, задовільний, базовий та високий. Оцінювання успішності з математики в учнів з порушеннями слуху проведено за чотирма напрямками навчальної програми з математики.

Результати. Проаналізовано результати посттесту учнів першого класу початкової школи з порушеннями слуху (158.95 MET, хв/тиждень) з метою порівняння середньої за інтенсивністю фізичної активності з результатами претесту (125.61 MET, хв/тиждень) під час занять фізичною культурою. Ходьба до школи (20.39 MET, хв/тиждень) та їзда на велосипеді до школи (16.85 MET, хв/тиждень) показали статистично значущі відмінності (між видами фізичної активності) у претесті та посттесті відповідно до MET $p<0.05$. Фізична активність сприяла досягненню учнями з порушеннями слуху базових результатів (претест (5.81 (3.25), посттест (16.84 (2.98); $p = 0.000$) та високих результатів (претест (0.81 (0.53), посттест (4.18 (0.47); $p = 0.002$).

Висновки. Згідно з результатами дослідження, було встановлено, що відповідно інтерпретована та доцільно застосована фізична активність для учнів початкової школи з порушеннями слуху призвела до статистично значущих змін у залежних змінних: підвищення фізичної активності учнів та академічної успішності. Суттєві зміни спостерігалися у завданнях з математики, що вимагали більш високого рівня розвитку розумових здібностей, знань та розуміння; розподіл навчальних досягнень з математики за змістом, як-от натуральні та цілі числа, закономірності та взаємозв'язки, геометрія та вимірювання, дані та статистичні ймовірності. Підвищений рівень фізичної активності зумовив зміну рівня навчальної успішності з задовільного до базового та високого.

Ключові слова: фізична активність, успішність з математики, учні з порушеннями слуху.

Information about the authors:

Kliziene, Irina: irina.kliziene@ktu.lt; https://orcid.org/0000-0003-1914-7355; Educational Research Group, Institute of Social Science and Humanity, Kaunas University of Technology, Kaunas 44249, Lithuania.

Sinkeviciene, Gintaute: pgintaute@gmail.com, Educational Research Group, Institute of Social Science and Humanity, Kaunas University of Technology, Kaunas, Lithuania.

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