Journal of Physical Education and Sport ® (JPES), Vol. 24 (issue 7), Art 193 pp. 1733 - 1742, July 2024
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Enhancing tactile sensitivity in 5th to 7th grade students with visual impairment through specifically oriented physical exercises

LILIANA RIADOVA[1], VLADYSLAV ROZHKOV[2], DARIUSZ V. SKALSKI[3], NATALIIA TSYHANOVSKA[4], OLEKSANDRA BAKANOVA[5], VIACHESLAV HONCHAR[6], VALENTYNA KRAMARENKO[7], VOLODYMYR KONOVALOV[8], OKSANA MKRTICHIAN[9]
[1, 5, 7]Department of Physical Education, Sports and Rehabilitation, National Aerospace University «Kharkiv Aviation Institute», UKRAINE,
[2]Department of Olympic and Professional Sports, Kharkiv State Academy of Physical Culture, UKRAINE,
[3]Department of Physical Culture, Jędrzej Śniadecki Academy of Physical Education and Sport, POLAND,
[4, 6]Department of Physical Culture and Health, Kharkiv State Academy of Culture, UKRAINE,
[8]Department of Physical Education and Sports, Kharkiv National University of Radio Electronics, UKRAINE,
[9]Department of Healthy Lifestyle, Technologies and Life Safety, Simon Kuznets Kharkiv National University of Economics, UKRAINE.

Published online: July 31, 2024
Accepted for publication : July 15, 2024
DOI:10.7752/jpes.2024.07193

Abstract:
Purpose: This research aims to improve the tactile sensitivity of 5th to 7th grade pupils with visual impairments. **Materials and Methods.** The study involved 102 pupils aged 10–13 years divided into experimental and control groups by grade and gender. Methods included theoretical analysis, synthesis of scientific literature, esthesiometry, pedagogical experiments, and statistical analysis IBM SPSS Statistics. Tactile sensitivity of the distal phalanx of the middle finger and palm center was assessed. Before the study, all participants underwent medical examinations without contraindications to physical activity. All parents were informed about the specifics of the study and provided written consent for their children to participate in the experiment. **Results of the research.** The increase of tactile sensitivity of the distal phalanx of the middle finger ($p<0,001$) and middle palm ($p<0,01–0,001$) was showed in visually impaired pupils of 5–7th grades of experimental groups under the influence of introduced specially oriented physical exercises. Traditional physical culture lessons for visually impaired pupils of the control groups didn't have a significant impact on the functional state of the tactile analyzer ($p>0,05$). The analysis of the obtained results revealed the following regularities: among the studied indicators the most significant improvement of the results of touch sensation on the distal phalanx of the middle finger was observed in girls, in the middle of the palm – in boys. **Conclusions.** The use of specially oriented physical exercises at physical culture lessons in 5–7th grade pupils with visual impairment of experimental groups contributed to a significant ($p<0,01–0,001$) improvement of tactile sensitivity indicators of distal phalanx of the middle finger and middle palm, which positively influenced the functional state of tactile sensory system in the specified contingent. To increase the sensitivity of tactile analyzers in 5–7th grade pupils with visual impairments, we recommend including the proposed physical exercises in the main part of physical culture lessons in the variable modules of athletics, football, basketball, volleyball, and gymnastics.
Key Words*:* **distal phalanx of the middle finger, middle of the palm, physical activity, pupils, tactile analyzer, visually impaired children**.

Introduction

The successful functioning of sensory systems is due to their interaction, which is manifested in the receipt by an individual of information that cannot be perceived without the joint activity of analyzers (Wickremasinghe et al., 2004; Magno et al., 2013). The tactile analyzer is one of the main ones in protecting from harmful external influences, making it possible to distinguish between touch, pressure, vibrations, heat, cold and pain (Filimonov, 2010; Gladkiy & Maikova, 2010). It is used to recognize objects, determine their shape, size, texture, deformation of bodies, and establish proportions and their ratio (Antonik et al, 2009; Lukyantseva, 2021). Rovny et al. (2015) emphasize that the tactile analyzer plays an important role in the perception of movements, as their performance is associated with stretching the skin and putting pressure on certain areas of it.

In sports activities, a tactile analyzer provides information about the amplitude of movements, body interaction with sports equipment; determines the speed of movement (Rovny, 2001; Zemtsova, 2008; Rovny et al., 2015). According to Nissim et al. (2024), tactile sensory experiences can stimulate visual functions and enhance sensory integration. Stavropoulou & Stavropoulos (2021) suggest that touch can create internal representations of parts of what can be seen.

Corresponding Author: LILIANA RIADOVA, E-mail: liaimago@gmail.com

The haptic analyzer is particularly important for people with visual impairments. They cannot receive full information about the world around them like people with normal vision because with residual vision alone.

Vision plays an important role in the physiological processes of environmental perception, spatial orientation, cognitive activity and coordination of movements. Most of the information that a person receives is transmitted through the visual analyzer (Riadova, 2024).

Matos et al. (2000) note that vision is essential for most human motor tasks and, according to Kapidis et al. (2024), plays an important role in performing precise and complex motor actions. According to the World Health Organization, 180 million people, including school-age children, suffer from visual deprivation worldwide (Savliuk et al., 2020). According to Nissim et al. (2024), visual impairment occurs due to various etiologies, including genetic diseases, prenatal or perinatal infections, preterm birth, trauma, and environmental influences.

Abnormalities in the functioning of the visual analyzer can be the result of various diseases and have a negative impact on health. In particular, prolonged use of computers and mobile devices can lead to visual impairment and cause other negative consequences. Therefore, it is important to follow the rules of vision prevention and correction, especially in the modern digital world. Insufficient attention to visual health can have serious consequences for a person's physical and mental development (Riadova, 2024).

According to Bukhovets et al. (2024), children with visual impairments lead a sedentary lifestyle, have physical inactivity and impaired spatial coordination. Nemček (2022) believes that it is necessary to involve visually impaired pupils in physical education. The tactile analyzer plays an important role in the lives of visually impaired people. The use of all types of tactile sensitivity expands and enriches the scope of perceptions and their imagery. Children with visual impairments have impaired spatial imagery, sensory cognition of the world, self-control and self-regulation (Bukhovets et al., 2023; Bukhovets, & Prokofieva, 2023).

Stafylidis (2023) highlights that the lack of visual information and visual feedback makes it difficult for people with visual impairments to develop social skills that are heavily dependent on their vision, which can affect how well they adapt to the social environment.

For visually impaired children, the tactile analyzer, in combination with the visual analyzer, helps them to create a complete image, navigate in space, learn and adapt to the environment (Kartava & Kosareva, 2010; Martynchuk et al., 2017; Sinyova & Fedorenko, 2018; Kostenko et al., 2019; Kostenko & Gudym, 2019).

The development of tactile sensitivity is particularly important for their adaptation and integration into society for children with visual impairments. Children with visual impairments often face difficulties in learning and socialization due to limited sensory perception, which can negatively affect their overall development.

Traditional physical education lessons don't take into account the specific needs of visually impaired pupils, which leads to insufficient development of their tactile sensitivity. The problem is the need to develop new methods that would effectively improve tactile sensitivity in children with visual impairments and compensate for the shortcomings of traditional approaches to physical education. Several researchers (Shesterova, 2004, 2015; Maslyak, 2007, 2008, 2015; Kuzmenko, 2013) have identified a positive impact of physical exercises on the functional state of the tactile sensory system in preschool and school-age children without visual impairment.

At the same time, specialists haven't dealt with the problem of improving the functional state of the tactile sensory system in visually impaired middle school children, so the issue of determining the effect of specially targeted physical exercises on the activity of the tactile analyzer in 5–7 grade pupils with visual impairments is an urgent research.

Pupils with visual impairments face numerous challenges in everyday life, including difficulties in learning and social adaptation. In view of this, we believe that improving tactile sensitivity in visually impaired children can have a positive impact on their socialization, allowing them to better navigate in space, perform everyday tasks and interact with the world around them.

To solve this problem, specially oriented physical exercises aimed at improving tactile sensitivity were introduced into the content of physical education lessons for visually impaired middle school pupils.

The results of the research have practical implications for the development of new physical education programs for visually impaired pupils, taking into account their specific characteristics, which will help improve their tactile sensitivity and overall well-being.

The purpose of the research was to improve the tactile sensitivity of 5th to 7th grade students with visual impairments. The hypothesis of the research was that the use of specially oriented physical exercises aimed at the activity of the tactile analyzer in physical education lessons for visually impaired pupils in grades 5–7 would improve tactile sensitivity in this contingent.

Materials & methods

The research involved 102 pupils of 5–7th grades of special boarding schools for children with visual impairments in Kharkiv and Kyiv, who were divided by grade and gender into six experimental and six control groups. The research lasted during the 2020–2021 academic year. All participants underwent a medical examination in the experiment and had no contraindications to physical activity.

All parents were informed about the specifics of the study and provided written consent for their children to participate in the experiment. The following methods were used to achieve the purpose of the research: theoretical analysis and synthesis of scientific literature; aesthesiometry; pedagogical experiment; statistical analysis. The theoretical analysis and synthesis of scientific literature made it possible to identify the key aspects of the research problem and form a theoretical basis for the experiment. Indicators of the spatial threshold of tactile sensitivity were determined using an esthesiometer (Weber compass).

The measurement was performed as follows: the subject sat on a chair with closed eyes, the legs of the compass were applied sequentially to the inner surface of the distal phalanx of the middle finger, and then to the middle of the palm of the right hand. The smallest distance between the compass legs (mm) was noted, at which the subject felt their touch as two separate sensations. The touch was repeated, gradually pushing the bars of the esthesiometer apart, each time increasing the distance between them by 1 mm. The minimum distance at which the subject felt two separate touches was recorded.

The norm of tactile sensitivity of the distal phalanx of the middle finger is 2.2 mm; the middle of the palm is 8.9 mm (Zhydenko, 2018). The indicators of tactile sensitivity of the distal phalanx of the middle finger and the middle of the palm were determined at the beginning of the research, to determine the functional state of the tactile analyzer in pupils of the experimental and control groups. These indicators were assessed at rest, in the same conditions and at the same time.

During the experiment, pupils of the control groups had lessons according to the Physical Culture Program for pupils of grades 5–10 with visual impairment developed by Sermeev & Pavlov (1995). The experimental group pupils additionally included physical exercises aimed at improving the sensitivity of the tactile analyzer in the variable modules of athletics, football, basketball, volleyball, and gymnastics in the main part of each physical culture lesson, in contrast to the Program proposed for control group pupils. Pupils of experimental groups were additionally offered to perform the following physical exercises: identification of objects, figures, numbers by touch with right and left hand; identification of shapes, sizes and nature of sports equipment surface during the athletics variable module in the main part of lessons.

Physical exercises were applied using the principle of opposing the thumb to other fingers of the hand; fingers of one hand to fingers of the other; and palms of both hands during the football variant module.

In physical culture lessons of the volleyball and basketball variable modules, it was proposed to perform movements with the fingers of one or two hands simultaneously, to determine the shape, size and nature of the surface of various objects, including balls.

The lessons of the gymnastics variable module included all of the above physical exercises.

During the application of these physical exercises, a repetitive method was used. The number of repetitions of each exercise was 6–12 times. At the end of the academic year, pupils of experimental and control groups reassessed tactile sensitivity of the distal phalanx of the middle finger and middle palm.

The statistical processing of the research results was carried out to interpret the data of the pedagogical experiment: to characterize the population by individual parameters, the arithmetic mean was calculated; to determine how the arithmetic mean obtained from the sample population differs from that which would be obtained from the general population - the representativeness error; to check the normality of the distribution of the obtained indicators – Shapiro-Wilk's test; Student's t-test was used to determine the reliability of differences between the indicators of groups with different sample sizes, linked samples with paired variants of observations, linked samples of the same size when comparing their elements by pair (Sergienko, 2010; Bondarenko, 2012; Kostiukevych et al., 2019; Antomonov et al, 2021).

All statistical data were processed in the statistical analysis program IBM SPSS Statistics version 28.0.1.0.

The research methods used, such as esthesiometry, pedagogical experiment and statistical analysis, allow for an objective assessment of the study results. The division of the participants into experimental and control groups ensures the correctness of the results and allows for a comparison between the effectiveness of traditional and specially oriented physical exercises in improving tactile sensitivity.

Results

There were no significant differences in tactile sensitivity of the distal phalanx of the middle finger and the middle of the palm of pupils of the experimental and control groups at the beginning of the research ($p>0,05$) (Table 1).

Table 1

Initial indicators of the tactile sensitivity in 5–7th grade pupils with visual impairment of experimental and control groups

Grade	Gender	Tactile sensitivity, mm						$t_{1,3}$*	$p_{1,3}$*	$t_{2,4}$**	$p_{2,4}$**
		Experimental groups			Control groups						
		n	Distal phalanx of the middle finger of the hand	The middle of the palm	n	Distal phalanx of the middle finger of the hand	The middle of the palm				
			$\overline{X} \pm \tilde{o}$			$\overline{X} \pm \tilde{o}$					
5	B	10	3,6±0,03	9,3±0,07	9	3,5±0,10	9,4±0,47	0,56	>0,05	0,53	>0,05
	G	8	3,5±0,05	9,4±0,12	9	3,2±0,08	9,8±0,12	0,85	>0,05	0,74	>0,05
6	B	12	3,3±0,06	9,7±0,14	8	3,6±0,23	9,3±0,71	0,79	>0,05	0,19	>0,05
	G	7	3,5±0,05	9,5±0,20	6	3,2±0,46	9,8±0,32	0,94	>0,05	0,27	>0,05
7	B	9	3,6±0,09	9,4±0,23	6	3,8±0,41	9,3±0,61	0,57	>0,05	0,47	>0,05
	G	11	3,4±0,01	9,6±0,24	7	3,2±0,61	9,9±0,10	0,64	>0,05	0,69	>0,05

Notes: *$t_{1,3}$; $p_{1,3}$ – reliability of difference in indicators of the tactile sensitivity of the distal phalanx of the middle finger in pupils of experimental and control groups before the experiment.
**$t_{2,4}$; $p_{2,4}$ – significance of difference in indicators of the tactile sensitivity of the middle palm of pupils of experimental and control groups before the experiment.

Comparison of indicators of the tactile sensitivity of the distal phalanx of the middle finger and middle palm in 5–7th grade pupils with visual impairments of experimental and control groups before experiment with normative data made it possible to establish that they are higher (worse) than the norm.
After using specially oriented physical exercises aimed at activating the activity of the tactile sensory system in pupils of the experimental groups, the indicators of tactile sensitivity of the distal phalanx of the middle finger and the middle of the palm in pupils of all studied classes improved significantly ($p<0,01–0,001$) (Table 2).

Table 2

Indicators of the tactile sensitivity in 5–7th grade pupils with visual impairment of experimental groups before and after the experiment

Grade	Gender	n	Tactile sensitivity, mm				$t_{1,3}$*	$p_{1,3}$*	$t_{2,4}$**	$p_{2,4}$**
			Before the experiment		After the experiment					
			Distal phalanx of the middle finger of the hand	The middle of the palm	Distal phalanx of the middle finger of the hand	The middle of the palm				
			$\overline{X} \pm \tilde{o}$		$\overline{X} \pm \tilde{o}$					
5	B	10	3,6±0,03	9,3±0,07	2,5±0,82	9,0±0,02	38,18	<0,001	8,14	<0,001
	G	8	3,5±0,05	9,4±0,12	2,2±0,45	8,9±0,01	25,04	<0,001	8,03	<0,001
6	B	12	3,3±0,06	9,7±0,14	2,7±0,64	9,1±0,02	46,84	<0,001	5,43	<0,001
	G	7	3,5±0,05	9,5±0,20	2,3±0,94	9,2±0,02	29,26	<0,001	3,93	<0,01
7	B	9	3,6±0,09	9,4±0,23	2,9±0,83	8,9±0,04	25,65	<0,001	3,43	<0,01
	G	11	3,4±0,01	9,6±0,24	2,2±0,71	9,1±0,03	37,58	<0,001	4,10	<0,001

Notes: *$t_{1,3}$; $p_{1,3}$ – significance of difference in indicators of the tactile sensitivity of the distal phalanx of the middle finger in pupils of experimental groups before and after the experiment.
**$t_{2,4}$; $p_{2,4}$ – reliability of difference in indicators of the tactile sensitivity of the middle palm of pupils of experimental groups before and after the experiment.

We determined increments of the tactile sensitivity to reveal the effectiveness of the application of the offered specially oriented physical exercises.

Under the influence of specially oriented physical exercises the increase of indicators of touch sensation on the distal phalanx of the middle finger in boys of the 5th grade was 30,56%, in the 6th grade – 18,2% and in the

7th grade – 19,4%. Girls showed the following increases in this indicator: the 5th grade – 37,1%, the 6th grade – 34,3% and the 7th – 35,3%.

The results of tactile sensitivity of the middle of the palm in boys of the 5th grade improved by 3,23%, the 6th grade – by 6,19% and the 7th grade – by 5,32%. In girls, sensitivity in this area of the skin increased by 5,32% in the 5th grade, by 3,16% in the 6th grade, and by 5,21% in the 7th grade.

The results obtained indicate a positive impact of the proposed specially oriented physical exercises on the functional state of the tactile analyzer in 5–7th grade pupils with visual impairments.

Boys mostly had a better tendency to improve the tactile sensitivity of the middle of the palm; girls had a greater tendency to increase the tactile sensitivity of the distal phalanx of the middle finger.

The repeated comparison of the studied indicators in middle school children with visual impairments of the experimental groups with the norms revealed that the results of touch sensation on the distal phalanx of the middle finger in girls of the fifth and seventh grades and in the middle of the palm in boys of the seventh and fifth grades correspond to the norms. They almost meet the norms for pupils of other grades.

The indicators of touch sensation on the distal phalanx of the middle finger and in the middle of the palm of control group pupils improved after the experiment, but insignificantly ($p>0,05$) and, as before the experiment, are higher (worse) than the norms (Table 3). This suggests that traditional physical culture lessons for control group pupils didn't have a significant impact on the tactile sensitivity of the skin areas.

Table 3

Indicators of the tactile sensitivity in 5–7th grade pupils with visual impairment of the control group before and after the experiment

Grade	Gender	n	Tactile sensitivity, mm				$t_{1,3}$*	$p_{1,3}$*	$t_{2,4}$**	$p_{2,4}$**
			Before the experiment		After the experiment					
			Distal phalanx of the middle finger of the hand	The middle of the palm	Distal phalanx of the middle finger of the hand	The middle of the palm				
			$\overline{X} \pm \tilde{o}$		$\overline{X} \pm \tilde{o}$					
5	B	9	3,5±0,10	9,4±0,47	3,2±0,82	9,3±0,16	1,51	>0,05	0,65	>0,05
	G	9	3,2±0,08	9,7±0,12	3,1±0,45	9,5±0,16	1,39	>0,05	0,91	>0,05
6	B	8	3,6±0,23	9,6±0,71	3,4±0,64	9,4±0,18	2,00	>0,05	1,47	>0,05
	G	6	3,2±0,46	9,8±0,32	3,1±0,94	9,6±0,15	1,51	>0,05	0,51	>0,05
7	B	6	3,8±0,41	9,3±0,61	3,6±0,83	9,2±0,27	1,37	>0,05	0,832	>0,05
	G	7	3,2±0,61	9,9±0,10	3,0±0,41	9,8±0,13	1,74	>0,05	0,49	>0,05

Notes: *$t_{1,3}$; $p_{1,3}$ – significance of difference in the tactile sensitivity of the distal phalanx of the middle finger in pupils of control groups before and after the experiment.
**$t_{2,4}$; $p_{2,4}$ – significance of difference in indicators of the tactile sensitivity of the middle palm of pupils of control groups before and after the experiment.

To reveal the effectiveness of traditional physical culture lessons we determined the growths of the tactile sensitivity indicators in pupils of control groups.
Increase in the tactile sensitivity of the distal phalanx of the middle finger in boys and girls of the 5th grade was 8,57% and 3,13%, respectively, in the 6th grade – 5,56% and 3,13%, respectively, and in the 7th grade – 5,26% and 6,25%, respectively.

Boys and girls of 5, 6 and 7 grades showed the following increases in the tactile sensitivity of the middle of the palm: 1,06% and 2,06%, 2,08% and 2,04%, and 1,085 and 1,01%, respectively.
Comparing the indicators of tactile sensitivity of the distal phalanx of the middle finger and the middle of the palm in 5–7th grade pupils with visual impairments of the experimental and control groups at the end of the study, we conclude that there are significant differences ($p<0,05–0,001$) between them (Table 4).

This indicates the effectiveness of the use of the proposed physical exercises aimed at improving the functional state of the tactile analyzer.

Table 4

Indicators of the tactile sensitivity in 5–7th grade pupils with visual impairments of experimental and control groups at the end of the research

Grade	Gender	Tactile sensitivity, mm						$t_{1,3}$*	$p_{1,3}$*	$t_{2,4}$**	$p_{2,4}$**
		Experimental groups			Control groups						
		n	Distal phalanx of the middle finger of the hand	The middle of the palm	n	Distal phalanx of the middle finger of the hand	The middle of the palm				
			$\overline{X} \pm \tilde{o}$			$\overline{X} \pm \tilde{o}$					
5	B	10	2,5±0,82	9,0±0,02	9	3,2±0,82	9,3±0,16	18,01	<0,001	3,51	<0,001
	G	8	2,2±0,45	8,9±0,01	9	3,1±0,45	9,3±0,16	10,16	<0,001	3,26	<0,01
6	B	12	2,7±0,64	9,1±0,02	8	3,4±0,64	9,4±0,18	9,86	<0,001	2,94	<0,01
	G	7	2,3±0,94	9,2±0,02	6	3,1±0,94	9,6±0,15	8,15	<0,001	3,38	<0,01
7	B	9	2,9±0,83	8,9±0,04	6	3,6±0,83	9,2±0,27	8,72	<0,001	2,72	<0,05
	G	11	2,2±0,71	9,1±0,03	7	3,0±0,41	9,8±0,13	9,93	<0,001	3,66	<0,01

Notes: *$t_{1,3}$; $p_{1,3}$ – significance of difference in indicators of the tactile sensitivity of the distal phalanx of the middle finger in pupils of experimental and control groups at the end of the research.
**$t_{2,4}$; $p_{2,4}$ – significance of differences in the tactile sensitivity of the middle palm of pupils of experimental and control groups at the end of the research.

Discussion

The tactile analyzer plays an important role in teaching and adaptation of visually impaired children to the environment. By defining the main functions of the tactile analyzer, the study emphasizes its role in perceiving different types of touch, movement and other stimuli that play an important role in everyday life and sports activities.

According to Wickremasinghe et al. (2004), Magno et al. (2013), a high level of functioning of the tactile sensory system can help compensate for visual impairment, as it plays an important role in the perception and analysis of various types of external and internal irritants, and in the formation of movements. However, as noted by Krutsevich et al. (2018), in the case of low vision, vision remains the main way of perceiving external information, and other analyzers don't replace visual functions, which is the case with blindness.

The development of tactile sensitivity is an important element of a child's overall development, contributing to their physical, cognitive and social growth:

– touch sensitivity contributes to motor skills, coordination and the ability to perform a variety of tasks such as writing, drawing or building;

– tactile experiences can improve children's cognitive development, helping them to better understand their environment and learn new things through touch;

– touch sensitivity promotes social interaction - children learn to perceive and respond to the touch of others.

Tactile sensitivity (the ability to feel and respond to touch) is important for children with visual impairments because they can use this channel of perception to receive additional signals about the world around them. This could help them better understand objects, structures and shapes, and interact with their environment.
The high level of sensitivity of the tactile analyzer can help children with visual impairments to develop spatial imagination, improve coordination of movements and contribute to their overall cognitive development. This approach can also facilitate social interaction and communication between children and other people.

Increasing the sensitivity of the tactile analyzer in children with visual impairments contributes to better adaptation to the world around them and the development of their abilities.

A comparison of the initial and repeated indicators of tactile sensitivity of the distal phalanx of the middle finger and the middle of the palm in 5–7th grade pupils of the experimental groups shows that after the experiment they have significantly ($p<0,01–0,001$) improved. The obtained data confirm the studies of Shesterova (2004), Masliak (2007), Kuzmenko (2013), Shesterova et al. (2017) on the positive impact of specially oriented physical exercises on the functioning of sensory systems, in particular the tactile one.

Traditional physical culture lessons conducted for 5–7th grade pupils with visual impairments in the control groups didn't have a significant effect on the tactile sensitivity of the skin areas under study. This emphasizes the importance of specially targeted physical exercises for achieving positive results in improving the functional state of the tactile analyzer.

Traditional physical culture classes tend to focus on general physical development and physical exercises aimed at improving the development of physical qualities. While this is important for health, such lessons may not provide sufficient stimulation for the development of the tactile analyzer, the sensory system responsible for perceiving touch, temperature, pain and other tactile sensations.

The results of the research showed that specially oriented physical exercises have significant potential to increase the sensitivity of the tactile analyzer in 5–7th grade pupils with visual impairments. Positive changes, which consisted of increasing the response of the tactile analyzer to external irritants, indicate the importance of specially oriented physical exercises as an effective means of influencing the functional state of the tactile sensory system in pupils with visual impairments. This positive effect may be caused by an increase in blood supply to the hands and stimulation of skin nerve receptors during specially targeted physical exercises. This approach to physical education can be beneficial for pupils with visual impairments, as it helps to improve their tactile sensitivity and contributes to their overall psychophysical development. Long-term and systematic training will be effective for long-term maintenance of the gains made by 5–7th grade pupils with visual impairments as a result of using specially targeted physical exercises in physical culture classes and further improvement of tactile sensitivity. Studies have shown that specially targeted physical exercises help to improve the functional state of the tactile analyzer, helping pupils to better distinguish between touch, pressure, vibrations and other important sensory sensations.

Developing the sensitivity of the tactile analyzer can help improve adaptation to the environment, spatial perception, learning outcomes and general well-being in pupils with visual impairments. This plays an important role in improving the quality of life and education of this population.

The research revealed a better tendency for boys to improve the tactile sensitivity of the middle of the palm, while girls showed a greater tendency to improve the results of tactile sensitivity of the distal phalanx of the middle finger. This confirms the data of Filimonov (2021), who believes that differences in the results of pupils are because the thresholds of tactile sensitivity are individual for each person.

The reasons for the difference in touch sensitivity on the distal phalanx of the middle finger and the middle of the palm in boys and girls could be:

– be due to genetic differences between the sexes that can affect the development and functioning of the nervous system;

– be related to different types of physical activity engaged in by boys and girls, for example, it is possible that certain sports may contribute to the improvement of tactile sensitivity in certain areas of the skin of the hands;

– there may be socio-cultural factors that can play a role in the formation of these differences, for example, stereotypes about what boys and girls should be like, may affect their interests, which affects the development of different tactile sensitivity functions.

Before and after the experiment, the indicators of touch sensation on the distal phalanx of the middle finger in 5–7th grade pupils with visual impairments in the experimental and control groups were significantly better than in the middle of the palm. This, according to Zhydenko (2018), is because the threshold of discrimination for different parts of the body is different.

The distal phalanx of the middle finger may perform better than the middle of the palm due to the difference in the number and location of touch receptors in these areas. The distal phalanges of the fingers have more nerve endings, the so-called Meissner's bodies, which perceive light touch and vibrations. Also, in these areas, the skin is thinner and closer to the nerve endings, which can improve the sense of touch. In the middle of the palm, the skin is thicker and has fewer touch receptors, so the sense of touch may be less sensitive.

During the experiment, the indicators of tactile sensitivity of the distal phalanx of the middle finger and the middle of the palm of the control group improved, but the changes were insignificant ($p>0,05$). We attribute this to the fact that with the systematic active use of touch sensations in everyday life, the sensitivity of the tactile analyzer increases.

We also believe that the improvement in tactile sensitivity in control group pupils who participated in traditional physical culture classes is due to

– variety of exercises: doing different physical exercises can help improve the tactile sensitivity;

– favorable environment: physical activity improves blood circulation, which can have a positive effect on the nervous system, including the tactile sensitivity;

– development of motor skills: physical activity helps to develop motor skills and movement control, which can have a positive impact on the perception and response to different types of touch;

– emotional state: exercise can help reduce stress and improve mood, which in turn can have a positive impact on tactile sensitivity;

– communication and collaboration: interacting with other pupils during physical activities that often require collaboration and communication can help develop tactile sensitivity through the perception of movement and touch.

The pupils of the experimental groups who performed specially oriented physical exercises in the main part of the variable modules of physical culture (athletics, football, volleyball, and gymnastics) showed

significantly better results of tactile sensitivity compared to the pupils of the control groups. This indicates that these exercises do have a positive effect on the development of the tactile analyzer in children with visual impairments.

The results of the research confirm previous research that has shown that specially targeted physical exercises can improve the functional state of the tactile sensory system in children without visual impairment. However, our work has expanded this field of research by showing that this approach is also effective for children with visual impairment.

Our work has practical implications for teachers, coaches and parents of children with visual impairments. Incorporating specially targeted physical exercises into their daily life and education may help to improve the functional state of the tactile analyzer.

Conclusions

The analysis of scientific and methodological literature shows the importance of haptic analyzers for the successful functioning of sensory systems and protection against external influences. It plays a significant role in recognizing objects, determining their characteristics and interacting with the environment.

The use of the proposed specially oriented physical exercises in physical culture lessons for pupils of grades 5–7th with visual impairment of the experimental groups contributed to a significant ($p<0,01–0,001$) improvement in the tactile sensitivity of the distal phalanx of the middle finger and the middle of the palm. This had a positive effect on the functional state of the tactile analyzer in this contingent.

The study revealed a positive effect of specially targeted physical exercises on the functional state of the tactile analyzer. This is confirmed both in previous studies with children without visual impairment and in the current study with pupils of grades 5–7th with visual impairment.

The use of specially targeted physical exercises significantly increases the sensitivity of the tactile analyzer in children with visual impairments. This indicates their effectiveness in improving the perception of touch and the ability to respond to tactile irritants.

Traditional physical culture lessons didn't have a significant impact on the functional state of the tactile analyzer in visually impaired pupils of the control groups.

The results of comparing the indicators of touch sensation on the distal phalanx of the middle finger and the middle of the palm in pupils with visual impairments of the experimental and control groups emphasize the effectiveness of specially targeted physical exercises in improving the sensitivity of the tactile analyzer in this contingent.

The results of our research indicate that the systematic use of specially targeted physical activity can help improve the functional state of the tactile sensory system in children with visual impairments.

Comparing gender differences in tactile sensitivity, it was found that boys showed a better tendency to improve the tactile sensitivity of the middle palm, while girls showed a greater tendency to increase tactile sensitivity of the distal phalanx of the middle finger.

To increase the sensitivity of the tactile analyzer in 5–7th grade pupils with visual impairments, we recommend including the proposed specially oriented physical exercises in the physical culture curriculum and using them in the main part of lessons in the variable modules of athletics, football, basketball, volleyball, gymnastics to achieve maximum effect. This can help improve the quality of life for visually impaired pupils. However, it is important to ensure that these exercises are appropriate and accessible to all pupils, taking into account their characteristics, needs and abilities.

Given the positive impact of specially targeted physical exercises on the activity of the tactile analyzer, it is possible to develop programs and techniques aimed at improving the functional state of sensory systems in pupils with various types of visual impairment.

Optimizing the physical culture curriculum for pupils with visual impairments can have a significant positive impact on their health and development.

As the results of the research demonstrate the potential of specially targeted physical exercises in improving the functional state of the tactile analyzer in children with visual impairment, this study may have a significant impact on the development of the implementation of curricula for pupils with visual impairment.

The results of our research can serve as a basis for further scientific research in the field of special education and physical education of children with visual impairments. In the future, the scope of the study could be expanded to include not only pupils from mainstream schools, but also primary and secondary schools, and to consider the long-term effects of different types of specially targeted physical exercises on the sensitivity of the tactile analyzer in children with visual impairments. Additional research may help to better understand the mechanisms of this process and develop more effective approaches to working with pupils with different types of visual impairment.

Conflicts of interest. The authors declare that no conflicts of interest exist.

References:

Antomonov, M. J., Korobeynikov, G. V., Khmelnytska, I. V., & Kharkovlyuk-Balakina, N. V. (2021). *Mathematical methods of processing and modeling the results of experimental research*: a textbook. Kyiv: Olympic literature [in Ukrainian].

Antonik, V. I., Antonik, I. P., & Andrianov, V. E. (2009). *Anatomy, physiology of children with the basics of hygiene and physical culture: a textbook.* Kyiv: Professional [in Ukrainian].

Bondarenko, I. G. (2012). *Sports metrology: methodological recommendations*. Mykolaiv: Petro Mohyla Black Sea State University [in Ukrainian].

Bukhovets, B. O., Romanenko, S. S., & Pokropyvnyi, O. M. (2023). Peculiarities of physical development in children with visual impairment. Rehabilitation & Recreation*, 14, 186–192. doi: https://doi.org/10.32782/2522-1795.2023.14.22 [in Ukrainian].*

Bukhovets, B. O., & Prokofieva, L. O. (2023). On the manifestation of motor disorders in children with visual deprivation. *Rehabilitation & Recreation*, 17, 165–170. doi: https://doi.org/10.32782/2522-1795.2023.17.20 [in Ukrainian].

Bukhovets, B. O., Kashuba, V. O., & Kucherenko, G. V. (2024). Comparative analysis of anthropometric indicators of 11-year-old children with visual impairment in comparison to their healthy peers. *Rehabilitation & Recreation*, 18, 1, 148–155. DOI: https://doi.org/10.32782/2522-1795.2024.18.16

Filimonov, V. (2010). *Human physiology*. Kyiv: Medicine [in Ukrainian].

Filimonov, V. (2021). *Human Physiology*. 4th edition, stereotyped. Kyiv: Medicine [in Ukrainian].

Gladkiy, T. V., & Maikova, G. V., compilers. (2010). *Basic physiological concepts, figures, definitions in the course «Human and animal physiology»: questions for test tasks*. Odesa: Astroprint [in Ukrainian].

Kapidis, P., Giannousi, M., Vernadakis, N., Papastergiou, M., Zetou, E., & Antoniou, P. (2024). Enhancing elementary school students' visual perceptual skills: a comparative study of oculus quest 2 exergames and conventional activities. *Sport Mont*, 22 (2), 139–146.

Kartava, Y. A., & Kosareva, N. O. (2010). *A child with visual impairment in inclusive education.* Sumy: Sumy State Pedagogical University named after A. S. Makarenko [in Ukrainian].

Kostenko, T. M., Gudym, I. M., Legky, O. M., & Kondratenko, S. V. (2019). *Features of standardization of the content of education of children with visual impairments*. Kyiv: FOP Simonenko O. I. [in Ukrainian].

Kostenko, T. M., & Gudym, I. M. (2019). *Teaching children with visual impairments*. Kharkiv: Ranok [in Ukrainian].

Kostiukevych, V. M., Shynkaruk, O. A., Voronova, V. I., & Borisova, O. V. (2019). *Fundamentals of research work of higher education students in the specialty «Physical Culture and Sports»*. Kostiukevych V. M., Shynkaruk A. A. Shynkaruk, editors. 2nd edition, unchanged. Kyiv: Olympic literature [in Ukrainian].

Krutsevich, T. Y., Pangelova, N. E., & Krivchikova, O. D. (2018). *Theory and methods of physical education*. in 2 vols. 3rd edition, unchanged. Kyiv: Olympic literature, 2 [in Ukrainian].

Kuzmenko, IO. (2013). Development of coordination abilities of middle school students taking into account the functional state of sensory functions. *Extended abstract of candidate's thesis*. Kharkiv: KHDAFK [in Ukrainian].

Lukyantseva, G. V. (2021). *Human Physiology*. 2nd edition, unchanged. Kyiv: Olympic literature [in Ukrainian].

Magno, E., Silva, M., Bilzon, J., Duarte, E., Gorla, J., & Vital, R. (2013). Sport injuries in elite Paralympic swimmers with visual impairment. *Journal of Athletic Training*, 48 (4), 493–498. doi: https://doi.org/10.4085/1062-6050-48.4.07.

Martynchuk, O. V., Marunenko, I. M., & Lutsko, K. V. (2017). *Special pedagogy*. Kyiv: Borys Hrinchenko Kyiv University [in Ukrainian].

Masliak, I. P. (2007). Changing the level of physical fitness of junior schoolchildren under the influence of special exercises aimed at improving the functional state of analyzers. *Extended abstract of candidate's thesis*. Kharkiv: KHDAFK [in Ukrainian].

Masliak, I. P. (2008). Dynamics of the level of physical fitness of junior schoolchildren under the influence of special exercises aimed at improving the functional state of analyzers. *Theory and methods of physical education and sports*, 4, 47–51 [in Ukrainian].

Maslyak, I. (2015). Influence of specially directed exercises on separate functions of sensor-based systems of pupils of junior classes. *Slobozhanskyi herald of science and sport*, 5 (49), 48–51 [in Ukrainian]. doi: https://doi.org/10.15391/snsv.2015-5.

Matos, R., Cruz, J., Amaro, N., Coelho, L., Morouço, P., & Rebelo-Gonçalves, R.(2000). Constraining of peripheral vision reduces standing long jump performance in children. *Journal of Physical Education and Sport*, 20 (4), 239, 1762–1767.

Nemček D. (2022). Children's attitudes towards inclusion of visually impaired students in physical education classes: gender differences. *Physical Education Theory and Methodology*, 22, 3, 423–429.

Nissim, M., Koslowe, K., Porre, Ya. R., Alter, E., & Tirosh R. (2024). Effectiveness of aquatic motor intervention on motor skills and adjusting to aquatic environments among toddlers with visual impairment: a pilot study. *Journal of physical education and sport,* 24 (5), 119, 1040–1047.

Riadova, L. (2024). Substantiation of the effectiveness of special exercises for eye muscles. *Kultura fizyczna i bezpieczeństwo w aktualizowaniu wartości zdrowia*. *Wybrane aspekty.* Starogard Gdański – Charków, 115–174 [in Ukrainian].

Rovny, A. S. (2001). The mechanism of sensory control of precise movements of athletes during a training session. *Theory and methods of physical education and sports,* 1, 31–34 [in Ukrainian].

Rovny, A. S. (2001). *Sensor mechanisms for controlling precise human movements*. Kharkiv: KHDAFK [in Ukrainian].

Rovny, A. S., Ilyin, V. M., Lizogub, V. S., & Rovna, O. O. (2015). *Physiology of sports activity*. Kharkiv: KHNADU [in Ukrainian].

Savliuk, S., Kashuba, V., Vypasniak, I., Yavorskyy, A., Kindrat, P., Grygus, I., Vakoliuk, A., Panchuk, I., & Hagner-Derengowska, M. (2020). Differentiated approach for improving the physical condition of children with visual impairment during physical education. *Journal of Physical Education and Sport*, 20 (2), 136, 958–965.

Sermeev, B. V., & Pavlov, Yu. V., compilers. (1995). *Physical education programs for visually impaired students: 5–10 grades*. Kyiv: ISDO [in Ukrainian].

Sergienko, L. P. (2010). *Sports metrology: theory and practical aspects*: textbook. Kyiv: KNT [in Ukrainian].

Sinyova, E. P., & Fedorenko, S. V. (2018). *Typhlopedagogy*. Kyiv: Drahomanov National Pedagogical University [in Ukrainian].

Shesterova, L. E. (2004). Influence of the level of activity of sensory functions on the improvement of motor abilities of middle school students. *Extended abstract of candidate's thesis*. Kharkiv: KHDAFK [in Ukrainian].

Shesterova, L. (2015). Influence of paropsiss is on the separate indexes of the functional state of the sensory systems of schoolboys of middle classes. *Slobozhanskyi herald of science and sport*. Kharkiv: HDAFK, 4, 46–51. doi: https://doi.org/10.15391/snsv.2015-4.

Shesterova, L., Kuzmenko, I., & Masliak, I. (2017). Motive preparedness of school-age children under the influence of special exercises affecting the state of the acoustic analyser. *Sport science: International scientific journal of kinesiology.* Travnik, Bosnia and Herzegovina, 10, 2, 96–104.

Stafylidis, A. (2023). The effect of physical activity on self-esteem of people with visual impairments. *Journal of physical education and sport*, 23 (9), 272, 2368–2375.

Stavropoulou, G., & Stavropoulos N. (2021). Association between team sports and anxiety with reaction time of individuals with visual impairment versus individuals with normal vision. *Trends in sport sciences*, 28 (2), 117–125.

Wickremasinghe, S., Foster, P. J., Uranchimeg, D., Lee, P. S., Devereux, J. G., Alsbirk, P. H., Machin, D., Johnson, G. J., & Baasanhu, J. (2004). Ocular biometry and refraction in Mongolian adults. *Investigative Ophthalmology and Visual Science*, 45 (3), 776–783. doi: https://doi.org/10.1167/iovs.03-0456.

Zemtsova, I. I. (2008). *Sports physiology*. Kyiv: Olympic literature [in Ukrainian].

Zhydenko, A. O. (2018). *Study guide to the course «Human Physiology» for students of the Faculty of Physical Education*. Chernihiv: National University «Chernihiv Collegium» named after T. G. Shevchenko [in Ukrainian].