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CHANGES IN THE PSYCHOMOTOR REACTIONS OF SIX AND SEVEN-YEAR-OLD CHILDREN WHEN APPLYING PHYSICAL THERAPY

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Abstract

The aim of the research is to evaluate the change in the psychomotor reactions of six and seven-year-old children when applying physical therapy. The research involved children at the age of six and seven years. It aimed at evaluating both the change in the speed of the psychomotor reactions of these children's free upper limbs to light while applying physical therapy, and the change in the speed of the psychomotor reactions of free upper limbs to sound while applying physical therapy. The research sample consisted of 270 children. Methods. The research data was collected by employing a method of testing using a reactiometer. The surveyed were divided into two research groups, which underwent different programmes in physical therapy exercises twice a week for the duration of six weeks. Group 1 underwent a physical therapy exercise programme comprising introductory, main and final parts (warm-up exercises, exercises developing coordination, and relaxation exercises); Group 2 also underwent a physical therapy programme comprising introductory, main and final parts (warm-up exercises, exercises developing the coordination, and exercises developing the psychomotor reactions to light and sound as well as relaxation exercises). The research data (testing) was collected before starting applying the physical therapy programme, and six weeks later. Results. The research results revealed that the results between the groups differed. The average reaction time was shorter in Group 2, which means that the tasks were completed faster. In Group 1, the shortest reaction time was 283 ms, and the longest was 650 ms. In Group 2, the shortest reaction time was 284 ms, and the longest was 456 ms. Conclusions. When applying physical therapy jointly with purposive exercises that develop the speed of psychomotor reactions, results can be achieved over the shortest period of time substantiated in scientific papers, i.e. six weeks.

KEY WORDS: children, psychomotor reactions, physical therapy.

Anotacija

Šio tyrimo tikslas – įvertinti 6–7 metų vaikų psichomotorinių reakcijų kitimą taikant kineziterapiją. Tyrime dalyvavo 6–7 metų vaikai. Siekta įvertinti vaikų viršutinių galūnių psichomotorinių reakcijų į šviesą ir garsą greičio kitimą taikant kineziterapiją. Tyrimo imtį sudarė 270 vaikų. Tyrimo duomenys surinkti taikant tyrimo metodą rekciometru. Tyrimo dalyviai suskirstyti į dvi grupes, kurioms šešias savaites du kartus per savaitę taikytos skirtingos kineziterapijos pratimų programos. Pirmai grupei pritaikyta kineziterapijos pratimų programa, kurią sudarė: įvadinė, pagrindinė ir baigiamoji dalys (apšilimo pratimai, koordinaciją lavinantys ir atpalaiduojantys pratimai); antrai grupei taikyta kineziterapija su įvadine, pagrindine ir baigiamąja dalimi (apšilimo, koordinaciją ir psichomotorines reakcijas į šviesą bei garsą lavinantys ir atpalaiduojantys pratimai). Tyrimo duomenys rinkti prieš pradedant taikyti kineziterapijos programą ir po šešių savaičių. Tyrimo rezultatai tarp grupių skyrėsi. Antroje grupėje vidutinis reakcijos laikas buvo trumpesnis, tai reiškia, kad užduotys buvo atliekamos greičiau. Pirmoje grupėje trumpiausia reakcijos trukmė – 283 ms, ilgiausia – 650 ms. Antroje grupėje trumpiausia reakcijos trukmė – 284 ms, ilgiausia – 456 ms. Taigi taikant kineziterapiją kartu

su tiksliniais psichomotorinės reakcijos greitį lavinančiais pratimais, rezultatų galima pasiekti per trumpiausią moksliniuose darbuose pagrįstą laiką – 6 savaites.
PAGRINDINIAI ŽODŽIAI: vaikai, psichomotorinės reakcijos, kineziterapija.

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Introduction

The development and characteristics of the human motor system, motor behaviour and movement control have been the object of scientific investigations for many years (Zuozienė et al., 2007). If the importance of physical exercise to the psychomotor reactions of children has been investigated quite extensively, the effect of purposive physical therapy exercises on the change in children's psychomotor reactions has been insufficiently researched (Newell et al., 2003; Schmidt, Lee, 1999; Parham, 2002). There are no doubts today about the motor system being attributed to complex, dynamic and adaptive systems (Zuozienė et al., 2007; Skurvydas, 2020; Muckus, 2003). Various physical exercises have a specific effect on the time and frequency of the motions of a psychomotor reaction. The frequency of motions and the time of a psychomotor reaction are some of the main indicators of speed that can be investigated under laboratory conditions. The pace of motions depends on the mobility of the central nervous system. The maximal frequency of motions demonstrates the level of the organism's psychomotor functions. Having registered the frequency of motions of one part of the body, we can judge the capacity of other muscles to perform frequent motions. There is quite a close relationship between separate groups of muscles performing frequently repeating cyclical motions (Kreivinienė, Vaitkienė, 2020; Newell et al., 2003).

The speed of a motion is a significant characteristic of a human's motion quality and efficiency; therefore, in the lives of both children and adults, people need adequate psychomotor reactions. The character of psychomotor reactions is determined by the performance of the cerebral hemispheres, the character of biochemical reactions, the speed of neural impulses, attention and the ability to focus on an activity, to plan it while making a motor decision, and precision when performing it (Mockevičienė, Žukauskaitė, Dobrovolskytė, 2013). A person's psychomotor reactions and their speed are a normal and adaptive reaction of a healthy organism helping to adapt quickly to the changed conditions of the environment and to prepare the organism for extreme changes which may require great efforts to be physically active. When facing a stimulus, the sympathetic nervous system and the core adrenal layer responsible for reacting rapidly to a stressor are activated (i.e. physiological reactions change: the heartbeat becomes faster, the blood pressure rises, the blood glucose level increases, etc): in just a few seconds the organism pre-

pares for successfully coping with difficulties (Perminas et al., 2013; Kreivinienė, Vaitkienė, 2020; Everitt, Skrondal, 2018). The reaction consists of three stages:

1. Sensory – a stimulus is perceived (in this case, seen and heard).
2. Associative – it is related to the person's awareness, i.e. that this is exactly the stimulus which a person must react to. Over this period, temporal nervous links between sight and motion analysers regenerate.
3. Motor: it is related to the occurrence of impulses in the motor region of the cortex and their spread through efferent neurons to particular muscles. The beginning of a motion, the first small movement, or 'stir', already belongs to the effectorial period, which encompasses a period of time from the beginning of a response motion to its end (Muckus, 2003).

Thus, everything starts from a sense, which is the ability to understand, recognise, assess or react to internal and external processes under the effect of the systems of the sensory organs: sight, hearing, taste, smell, touch and motion (Everitt, Skrondal, 2018). Authors suggest the most commonly used model for investigating the interdependency between speed and precision (Yan et al., 2000; Stergiou, 2004). In motor control theory, this model is known as Fitts' law (Yan et al., 2000). A small number of research studies analysing the indicators of time and speed in the child age range are available. However, there are no doubts about the motor system being attributed to complex, dynamic and adaptive systems (Kelso, 1999; Worpert, Ghahramani, Flanagan, 2001; Skurvydas, 2017). It is important to analyse assumptions not only about heredity having an effect on features of movement control in terms of human ontogenesis, but also circumstances (education, teaching and development) (Yan et al., 2000; Stergiou, 2004). Moreover, it is important to note how quick multimodal integration is, how fast the nervous system is able to integrate information from different sensory receptors, and how the direct effect of one sense may help perceive another sense (Kreivinienė, Vaitkienė, 2020; Gliga et al., 2014). For that reason, it is important to investigate the effect of purposive physical therapy programmes on the speed of children's psychomotor reactions.

Hypothesis. It is likely that when applying the interventions of a purposive physical therapy exercise programme to six and seven-year-old children, the reaction time changes positively (it becomes faster). It likely that the application of purposive physical therapy programme exercises chosen to purposefully develop coordination and changes in reactions to light and sound for children of this age for a period of six weeks allows for better results in the evaluation of the reaction measured by a reactionmeter.

Aim. To evaluate the effect of a physical therapy exercise programme on the speed of changes in the reactions of six and seven-year-old children's upper limbs to light and sound.

The research was conducted in compliance with all the ethics principles of good research practice. Ethical approval: all the procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and research committee, and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The research content was shown to the parents/foster parents of the surveyed. The surveyed participated in the research only after having informed their parents/foster parents and obtained written consent from their parents/foster parents. The participation of the surveyed in the research was on a voluntary basis: they had and were introduced to the opportunity to withdraw from the research at any time. Information on the purpose, proceedings and methods of data collection, and the form of data presentation, was provided to the parents/foster parents of the surveyed, and the research results obtained were presented to them. In the course of the research, laws and conventions protecting human rights, as well as legal acts protecting personal data, were complied with, confidentiality was assured, and the privacy and anonymity of the surveyed were not violated. In order to perform the research, all the required permissions were obtained according to the valid procedure in the institution where the research took place. The data obtained during the research was used only for scientific purposes.

1. Materials and Methods

1.1. Materials

In the present research evaluating the change of psychomotor reactions of six and seven-year-old children when applying physical therapy, two research objectives were set:

1. To evaluate the change in the speed of the psychomotor reactions of six and seven-year-old children's free upper limbs to light while applying physical therapy.
2. To evaluate the change in the speed of the psychomotor reactions of six and seven-year-old children's free upper limbs to sound while applying physical therapy.

Research participants. Purposive, convenience research sampling was applied. The research took place between 2017 and 2019. A total of 270 children participated in the research. The criteria for the selection of the research participants:

1. The child's age was six or seven years.
2. The child attended a nursery-kindergarten in Klaipėda, Plungė or Šiauliai.

3. The consent of parents/foster parents allowing their child to participate in the research.
4. The child's consent to participate in the research.

2.2. Methods

1. Testing. The evaluation of the speed of psychomotor reactions was performed by using a tool for the evaluation of psychomotor reactions, a reactionmeter (see Fig. 1). The purpose of the device was to evaluate the functional condition of the central nervous system and the speed of the psychomotor reactions. The device measured the frequency of motion. Testing was performed twice: before starting physical therapy exercises and after they ended. The following were evaluated:
   - the reaction of the upper limbs to light;
   - the reaction of the upper limbs to sound.
2. Experimentation. The experiment was performed while applying different physical therapy programmes to groups of children. Group 1 underwent a physical therapy exercise programme consisting of introductory, main and final parts (warm-up exercises, exercises developing coordination, and relaxation exercises). Group 2 also underwent a physical therapy programme, consisting of introductory, main and final parts (warm-up exercises, exercises developing the coordination, and exercises developing the psychomotor reactions to light and sound, as well as relaxation exercises). The experiment lasted six weeks. For a scheme of the experiment, see Fig. 2.

Figure 1. A reactiometer (RA-1, 'Baltec CNC Technologies', Lithuania)
Source: access via the Internet at http://www.sportija.lt/lt/reakcijos-testavimas/reakciometras-judesiu-daznio-matuoklis-286.html [accessed on 27 November 2020].

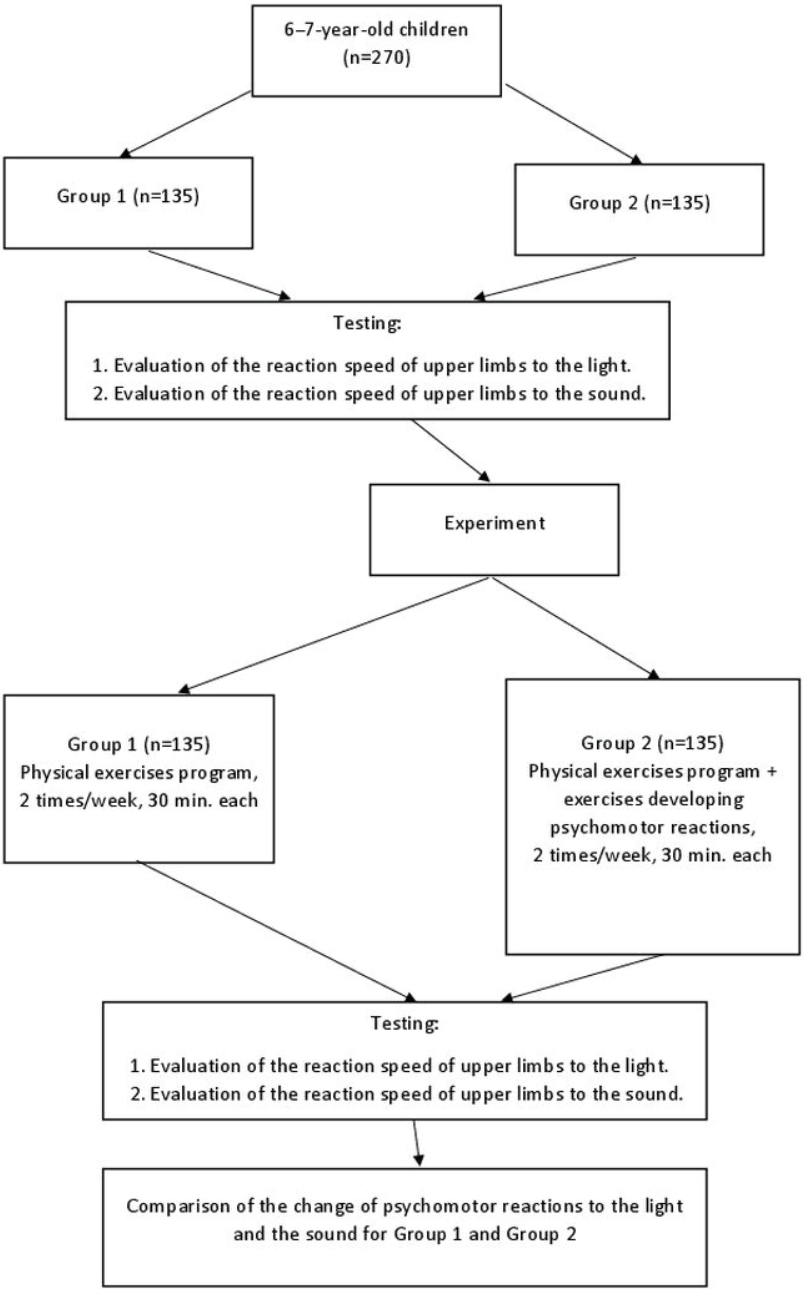

Figure 2. The scheme of the experiment

3. Statistical data analysis. The data obtained in the course of the research was systematised by the Microsoft Excel 2016 program. In order to visualise the results, the diagrams were designed by the Microsoft Word 2016 program.

The statistical data was analysed by calculating median, minimum and maximum values. To find the statistical significance, the level of statistical significance was calculated: when $p \leq 0.001$, features are significant, when $p > 0.001$, features are insignificant.

2. Results

2.1. The results of the speed of the psychomotor reactions of the upper limbs to light before physical therapy

Testing was performed for both groups twice, before applying the physical therapy programmes, and after all the physical therapy exercises lasting six weeks. Testing was performed using a reactionmeter, and each child had ten tries to complete the task. Having calculated all the tries, the following indicators were recorded: the shortest reaction time, the longest reaction time, and the average reaction time. Moreover, the number of mistakes made was also recorded.

The physical therapy programmes were applied twice a week (on Mondays and Wednesdays); the duration of the exercise session was 30 minutes. The programmes of physical therapy for children were applied from 4 March to 17 April 2019.

Results of the psychomotor reactions of the right arm, the left arm and both arms to light before physical therapy. When evaluating the psychomotor reactions of the right arm before physical therapy exercises, it can be observed that the results in the groups differed: the difference between the groups was 25 ms. The results obtained show that the average reaction time in Group 2 was shorter, so it means the exercises were performed faster (see Table 1). The parameters of psychomotor reactions to light before physical therapy are presented in Table 1.

Distribution of shortest and longest reaction times in the groups. In Group 1, the shortest reaction time was 283 ms, and the longest was 650 ms. In Group 2, the shortest reaction time was 284 ms, and the longest was 456 ms.

Number of mistakes in the groups. All the children in both groups performed the task without making mistakes.

When evaluating the psychomotor reactions of the left arm before physical therapy, it can be observed that the results between the groups differ slightly: the difference between the groups was 10 ms. An analysis of the research results has

revealed that the average reaction time in Group 1 was shorter, so it means the tasks were performed faster (see Table 1).

Distribution of shortest and longest reaction times in the groups. In Group 1, the shortest reaction time was 308 ms, and the longest was 527 ms. In Group 2, the shortest reaction time was 268 ms, and the longest was 670 ms.

Number of mistakes in the groups. In Group 1, 20 children made mistakes while performing the task. In Group 2, 71 children made mistakes while performing the task.

Results of the psychomotor reactions of both arms to light before physical therapy. When evaluating the psychomotor reactions of both arms before physical therapy, it can be observed that the results between the groups differ: the difference between the groups was 33 ms. An analysis of the research data has revealed that the average reaction time in Group 2 was shorter, and this means that the tasks were performed faster (see Table 1).

Distribution of shortest and longest reaction times in the groups. In Group 1, the shortest reaction time was 394 ms, and the longest was 848 ms. In Group 2, the shortest reaction time was 486 ms, and the longest was 757 ms.

Number of mistakes in the groups. In Group 1, 15 children made one mistake each, ten made two mistakes each, seven made three mistakes each, and five made four mistakes each. In Group 2, 20 children made one mistake each, and 17 made three mistakes each.

Table 1. Indicators of the reactions of the right arm, the left arm, and both arms, to light before physical therapy

Results of psychomotor reactions to light before physical therapy	**Distribution of average reaction time in the surveyed groups, ms**		**Parameters**			
	Group 1	**Group 2**	**Median**	**Minimum**	**Maximum**	**Statistical significance**
Right arm	362	337	186	320	372	$p > 0.001$
Left arm	377	387	195	370	390	$p > 0.001$
Both right and left arms	623	590	315	570	625	$p \leq 0.001$

2.2. The results of the speed of the psychomotor reactions of the upper limbs to light after physical therapy

The results of the psychomotor reactions of the right arm, the right arm and both arms to light after physical therapy. When evaluating the psychomotor reactions of the right arm after physical therapy, it can be observed that the results between the groups differ: the difference between the groups was 145 ms. The results obtained demonstrate that the average reaction time in Group 2 which underwent the physical therapy programme including exercises on the development of the coordination and psychomotor reactions to light and sound was shorter, and this means that the tasks were performed faster (see Table 2).

The distribution of shortest and longest reaction times in the groups. In Group 1, the shortest reaction time was 317 ms, and the longest was 1310 ms. In Group 2, the shortest reaction time was 301 ms, and the longest was 403 ms.

The number of mistakes in the groups. The children in both groups performed the task without mistakes.

When evaluating the psychomotor reactions of the left arm after physical therapy, it can be observed that the results between the groups do not differ (see Table 2).

The distribution of shortest and longest reaction times in the groups. In Group 1, the shortest reaction time was 268 ms, and the longest was 379 ms. In Group 2, the shortest reaction time was 272 ms, and the longest was 388 ms.

The number of mistakes in the groups. The children in both groups performed the task without mistakes.

When evaluating the psychomotor reactions of both arms after physical therapy, it can be observed that the results between the groups differ: the difference between the groups was 106 ms. An analysis of the research results has revealed that the average reaction time in Group 2 which underwent the physical therapy programme, including exercises on the development of the coordination and psychomotor reactions to light and sound, was shorter, so it means that the tasks were performed faster (see Table 2).

The distribution of shortest and longest reaction times in the groups. In Group 1, the shortest reaction time was 444 ms, and the longest was 736 ms. In Group 2, the shortest reaction time was 375 ms, and the longest was 651 ms.

The number of mistakes in the groups. In Group 1, five children made one mistake each, and two made two mistakes each. In Group 2, four children made one mistake each, and three made two mistakes each.

Table 2. Indicators of the reaction of the right arm, the left arm and both arms to light after physical therapy

Results of psychomotor reactions to light after physical therapy	**Distribution of the average reaction time in the surveyed groups, ms**		**Parameters**			
	Group 1	**Group 2**	**Median**	**Minimum**	**Maximum**	**Statistical significance**
Right arm	478	333	250	55	500	$p > 0.001$
Left arm	337	387	175	50	350	$p > 0.001$
Both right and left arms	600	494	300	50	600	$p \leq 0.001$

2.3. The results of the speed of the psychomotor reactions of the upper limbs to sound before physical therapy

The results of the psychomotor reactions of the right arm and the left arm to sound before physical therapy. When evaluating the psychomotor reactions of the right arm before physical therapy exercises, it can be observed that the results differ slightly between the groups: the difference between the groups was 11 ms. An analysis of the research results has revealed that the average reaction time in Group 1 was shorter, and this means that the tasks were performed faster (see Table 3).

The distribution of shortest and longest reaction times in the groups. In Group 1, the shortest reaction time was 249 ms, and the longest was 383 ms. In Group 2, the shortest reaction time was 270 ms, and the longest was 429 ms.

Number of mistakes in the groups. In Group 1, ten children made one mistake each, five made two mistakes each, and 12 made three mistakes each. In the surveyed Group 2, 15 children made one mistake each, ten made two mistakes each, and five made three mistakes each.

When evaluating the psychomotor reactions of the left arm before the physical therapy exercises, it can be observed that the results differ between the groups: the difference between the groups was 30 ms. The results obtained show that the average reaction time in Group 2 was shorter, so this means that the tasks were performed faster (see Table 3).

The distribution of shortest and longest reaction times in the groups. In Group 1, the shortest reaction time was 234 ms, and the longest was 508 ms. In Group 2, the shortest reaction time was 266 ms, and the longest was 385 ms.

The number of mistakes in the groups. All the children made mistakes in both groups. In the surveyed Group 1, 25 children made one mistake each, 13 made two mistakes each, and four made three mistakes each. In the surveyed Group 2, 30 children made one mistake each, 12 made two mistakes each, and three made three mistakes each.

Table 3. Indicators of the reactions of the right arm and the left arm to sound before physical therapy

Results of psychomotor reactions to sound before physical therapy	**Distribution of the average reaction time in the surveyed groups, ms**		**Parameters**			
	Group 1	**Group 2**	**Median**	**Mini-mum**	**Maxi-mum**	**Statistical sig-nificance**
Right arm	325	336	170	315	340	$p > 0.001$
Left arm	355	325	180	310	360	$p > 0.001$

2.4. The results of the speed of the psychomotor reactions of the upper limbs to sound after physical therapy

The results of the psychomotor reactions of the right arm and the left arm to sound after physical therapy. When evaluating the psychomotor reactions of the right arm after physical therapy exercises, it can be observed that the results differ between the groups: the difference between the groups was 50 ms. An analysis of the research results has revealed that the average reaction time in Group 2 which underwent the physical therapy programme, including exercises on the development of the coordination and psychomotor reactions to light and sound, was shorter, and it means that the tasks were performed faster (see Table 4).

The distribution of the shortest and longest reaction times in the groups. In Group 1, the shortest reaction time was 280 ms, and the longest was 393 ms. In Group 2, the shortest reaction time was 257 ms, and the longest was 360 ms.

The number of mistakes in the groups. In both groups, all the children completed the tasks making few mistakes. In Group 1, 20 children made one mistake each, and three made two mistakes each. In Group 2, ten children made one mistake each, and two made two mistakes each.

When evaluating the psychomotor reactions of the left arm after the physical therapy exercises, it can be observed that the results differ between the groups: the difference between the groups was 22 ms. An analysis of the research results has

revealed that the average reaction time in Group 2 which underwent the physical therapy programme including exercises on the development of the coordination and psychomotor reactions to light and sound was shorter, and this means that the tasks were performed faster (see Table 4).

The distribution of shortest and longest reaction times in the groups. In Group 1, the shortest reaction time was 267 ms, and the longest was 397 ms. In Group 2, the shortest reaction time was 232 ms, and the longest was 415 ms.

The number of mistakes in the groups. All the children in both groups performed the tasks making few mistakes. In Group 1, ten children made one mistake each, and one child made two mistakes. In Group 2, five children made one mistake each, and two made two mistakes each.

Table 4. Indicators of the reaction of the right arm and the left arm to sound after physical therapy

Results of psychomotor reactions to sound after physical therapy	**Distribution of the average reaction time in the surveyed groups, ms**		**Parameters**			
	Group 1	**Group 2**	**Median**	**Minimum**	**Maximum**	**Statistical significance**
Right arm	343	293	175	260	350	$p > 0.001$
Left arm	325	299	163	285	325	$p > 0.001$

3. Discussion

When comparing the research results for both groups, significantly better results were recorded for children who, seeking to obtain a better psychomotor response, participated not only in the physical therapy exercises, but also in the exercises developing psychomotor reactions. It is also called the multimodal integration of stimuli, because the nervous system is able to integrate information from different sensory receptors. In this case, the direct effect of one sensation may help perceive another sensation. This research is an example demonstrating that it is possible to reduce the time of a psychomotor reaction to a stimulus (the acuteness of the reaction) by performing purposive exercises while combining two programmes (Gliga et al., 2014).

3.1. A comparison of the psychomotor reactions of the upper limbs to light and sound before and after physical therapy

The change in the psychomotor reactions of the right arm to light before and after physical therapy in both groups. When evaluating the change in the psychomotor reactions of the right arm for both groups before and after physical therapy exercises, it can be observed that the results differ between the groups: in Group 1 the average reaction time increased by 116 ms, and in Group 2 the reaction time decreased by 44 ms. The results obtained demonstrate that the results were better for Group 2 which underwent the physical therapy programme, including exercises on the development of the coordination and psychomotor reactions to light and sound (see Table 5).

Table 5. A comparison of the indicators for the reaction of the right arm to light before and after physical therapy

Results of psychomotor reactions of the right arm to light	**Distribution of the average reaction time in the surveyed groups, ms**		**Parameters**			
	Before physical therapy	**After physical therapy**	**Median**	**Mini-mum**	**Maxi-mum**	**Statistical significance**
Group 1	326	442	250	50	500	$p > 0.001$
Group 2	377	333	250	50	500	$p < 0.001$

The change in the psychomotor reactions of the left arm to light before and after physical therapy in both groups. When evaluating the change in the psychomotor reactions of the left arm for both groups before and after physical therapy exercises, it can be observed that the results between the groups differ slightly, but they improved: in Group 1 the average reaction time decreased by 40 ms, in Group 2 the reaction time decreased by 50 ms. While analysing the research results, it was found that the results of Group 2, which underwent the physical therapy programme including exercises on the development of the coordination and psychomotor reactions to light and the sound, were better (see Table 6).

Table 6. A comparison of the indicators of the reactions of the left arm to light before and after physical therapy

Results of psychomotor reactions of the left arm to light	**Distribution of the average reaction time in the surveyed groups, ms**		**Parameters**			
	Before physical therapy	**After physical therapy**	**Median**	**Minimum**	**Maximum**	**Statistical significance**
Group 1	377	337	200	50	400	p <0.001
Group 2	387	337	200	50	400	p <0.001

The change in the psychomotor reactions of both arms to light before and after physical therapy in both groups. When evaluating the change in the psychomotor reactions of both arms for both groups before and after the physical therapy exercises, it can be observed that the results between the groups differ, but the results in both groups improved: in Group 1 the average reaction time decreased by 23 ms, and in Group 2 the time decreased by 96 ms. An analysis of the research results has revealed that the results from Group 2, which underwent the physical therapy programme including exercises on the development of the coordination and psychomotor reactions to light and sound, were better (see Table 7). Neurobiological investigations by authors (Parham, 2002) have proven that when a human uses particular skills and functions, synapsis mechanisms are enhanced, and, vice versa, neglected unused skills and functions weaken the synapsis links, and they might even be substituted by other functions.

Table 7. A comparison of the indicators of the reactions of both arms to light before and after physical therapy

Results of psychomotor reactions of both right and left arms to light	**Distribution of the average reaction time in the surveyed groups, ms**		**Parameters**			
	Before physical therapy	**After physical therapy**	**Median**	**Minimum**	**Maximum**	**Statistical significance**
Group 1	623	600	350	50	700	p >0.001
Group 2	590	494	350	50	700	p >0.001

The change in the psychomotor reactions of the right arm to sound before and after physical therapy in both groups. When evaluating the change in the psychomotor reactions of the right arm for both groups before and after the physical therapy exercises, it can be observed that the results between the groups differ: in Group 1 the average reaction time increased by 18 ms, and in Group 2 the reaction time decreased by 43 ms. The results obtained demonstrate that the results of Group 2, which underwent the physical therapy programme including exercises on the development of the coordination and psychomotor reactions to light and sound, were better (see Table 8).

Table 8. A comparison of the indicators of the reactions of the right arm to sound before and after physical therapy

Results of psychomotor reactions of the right arm to the sound	**Distribution of the average reaction time in the surveyed groups, ms**		**Parameters**			
	Before physical therapy	**After physical therapy**	**Median**	**Minimum**	**Maximum**	**Statistical significance**
Group 1	325	434	175	260	350	p <0.001
Group 2	336	293	175	260	350	p <0.001

Similar results were also obtained in scientific research by Bant et al. (1998) and Kreivinienė, Vaitkienė (2020). Psychomotor reactivity is individual to each human, depending on the surrounding factors and genetic heredity; however, for some it is higher, for others it is lower, and this is determined by many other factors. Special purposive parameters increasing psychomotor reactivity while taking part in specialised training, including physical parameters and physical activity, ensure better results. The most effective are training activities which develop motion, the ability to control physiological processes, which ensures the reactivity of the connective tissue and skeletal muscles. Special exercises and training programmes develop psychomotor reactions best, and prepare a human for faster psychomotor reactivity; they are the parameters of an individual response to a stimulus while demonstrating the qualified motor performance of a task.

The change in psychomotor reactions of the left arm to sound before and after physical therapy in both groups. When evaluating the change in the psychomotor reactions of the left arm for both groups before and after the physical therapy exercises, it can be observed that the results between the groups differ slightly, but the results in both groups improved: in Group 1 the average reaction time decreased by

34 ms, in Group 2 the reaction time decreased by 26 ms. When analysing the research results, it was found that the reaction time of Group 2, which underwent the physical therapy programme including exercises on the development of the coordination and psychomotor reactions to light and sound, was shorter, which means that the tasks were performed faster. Nevertheless, a higher increase in the results is also observed for Group 1, when evaluating the change in the psychomotor reactions of the left arm to sound before and after physical therapy (see Table 9).

This is also proven by other scientific research works (Kreivinienė, Vaitkienė, 2021; Kelso, 1990; Kreivinienė, Vaitkienė, 2020). Having said that, when sport and intense work are neglected, the psychomotor reactions start worsening faster, although simple reactions and their duration are usually determined by genetic hereditary factors; therefore, they can hardly be developed much (Schmidt, Lee, 1999).

Table 9. A comparison of the indicators of the reaction of the left arm to sound before and after physical therapy

Results of psychomotor reactions of the left arm to sound	**Distribution of the average reaction time in the surveyed groups, ms**		**Parameters**			
	Before physical therapy	**After physical therapy**	**Median**	**Minimum**	**Maximum**	**Statistical significance**
Group 1	355	321	180	270	360	p >0.001
Group 2	325	299	180	270	360	p >0.001

The changes in the results for Group 1 during the investigation. The results obtained in the course of the investigation demonstrated that physical therapy exercises had a positive effect on the results of Group 1. The changes in the results are visualised by the curves (see Fig. 3).

The changes in the results for Group 2 during the investigation. The results obtained in the course of the investigation were better for Group 2 (attending special exercises to develop psychomotor reactions), and this proves the statement of Zuozienė et al. (2007), putting it that the psychomotor reaction times can be improved, albeit slightly, by applying physical exercises when individuals must react to external stimuli (Bružas et al., 2018). The changes in the results are visualised by the curves (see Fig. 4).

This research demonstrates that when seeking to develop the speed of reactions, it is significantly more important to develop children not only by applying a physical therapy programme, but also by choosing special exercises to develop the

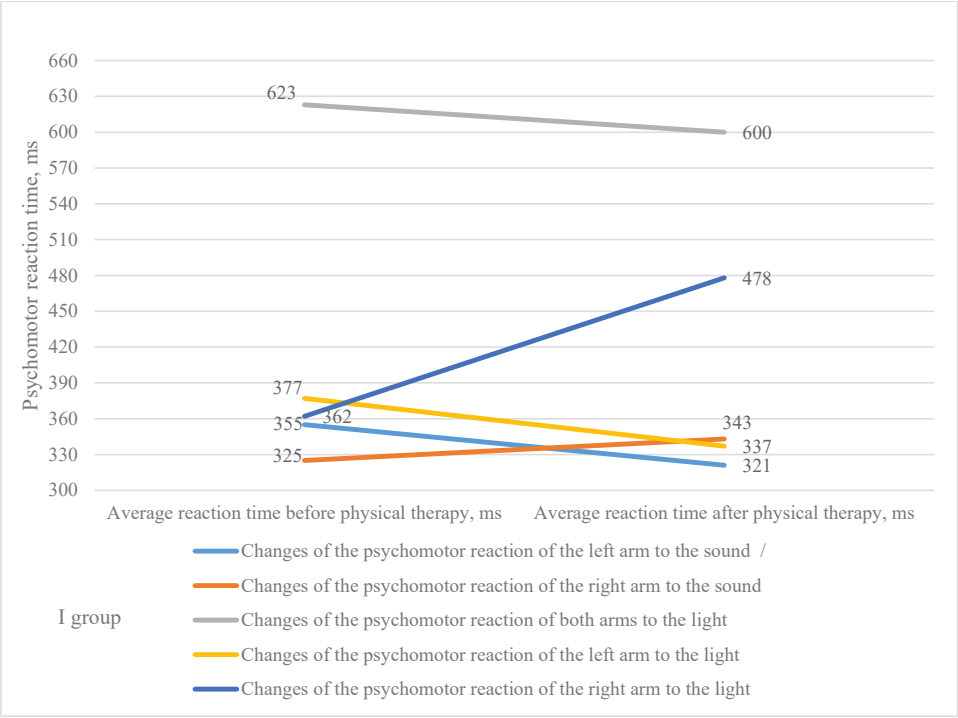

Figure 3. Changes in the results for Group 1 during the investigation (ms)

psychomotor reactions, and applying them together. In the course of this process, the nerve cells (neurons) send information from the environment and the sensory organs to medulla and encephalon, where it is processed by associative neurons. Information is then decoded and interpreted in the central nervous system (encephalon, brain in the spinal canal), and the brain allows for planning and coordinating this information and responding by a motor reaction. Sensations are necessary, like 'food for the brain', providing information and perception to the body and the consciousness. The complex processing of sensations allows the brain to accept information in an organised way, and to respond to it promptly in order to form an effective reaction in daily situations, and this proceeds according to a scheme (Gliga et al., 2014; Kreivinienė, Vaitkienė, 2020):

- focusing attention: maintenance of reaction to a chosen key stimulus;
- acceptance of new information from the environment: to react to useful information;
- seeking adequate reaction: to foresee the start of an action (we interpret sensations based on information obtained and experience gained);

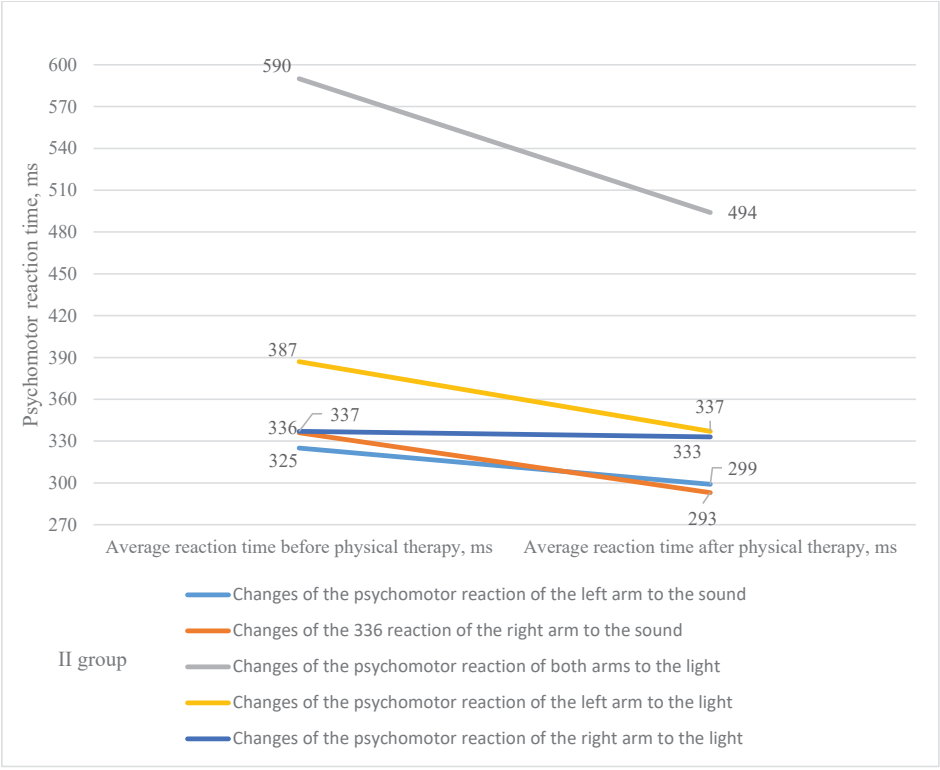

Figure 4. Changes in the results for Group 2 during the investigation (ms)

- spatial perception: the sensing of muscles and joints helps perform an action (in such a way that we become aware of which stimulus to react to immediately);
- adequate fast motor planning and direction of motion.

Many authors agree that psychomotor reactions increase until the age of 20 (Mockevičienė, Žukauskaitė, Dobrovolskytė, 2013). This psychomotor reactivity is highly important to further human life (Brouwer, Sale, Nordstrom, 2001). It is clear that the investigation of children's psychomotor reactions is necessary, because it can have an effect and can help in the future to choose a proper occupation, and influences one's daily activities and other daily choices. In Winifred W. Dunn's opinion, when choosing an occupation, first of all one must assess one's neurosensorimotor and psychomotor features. A properly selected occupation increases a person's functionality, whereas an improper one requires greater preparation and might cause additional stress (Kreivinienė, Vaitkienė, 2020; Bant et al., 1998; Jacobson, Mulick, Rojahn, 2007).

The duration of both an adult and a child's psychomotor reactions depends on the responsiveness of the receptors, the speed of impulse transmission, the speed of signal transmission in the central nervous system, decision-making, efferent signal transmission, and impulse transmission to muscles, and the speed of muscle fibre contraction. The reaction time also depends on many factors, such as sight and hearing. The time of the reaction also depends on focusing attention, and on the preparation to react to one or another stimulus. The more complex the stimulus, the greater the significance of concentration and the focusing of attention (Skurvydas, 2020). The quality of a psychomotor function is also related to a person's physical activity. The better the person's physical fitness, the faster the psychomotor reactions (Jacobson, Mulick, Rojahn, 2007; Skurvydas, 2020). After conducting the investigation, it was observed that the coordination of motions, eye-arm coordination, and the focusing of attention while performing various tasks also improved when developing psychomotor reactions. Thus, the assumption can be made that the development of psychomotor reactions is directly related to the academic activities of pre-school and pre-primary age children and positive results.

Conclusions

The results of the investigation into six and seven-year-old children's psychomotor reactions revealed significant findings. The speed of the psychomotor reactions of boys and girls does not usually differ at this age, the differences are caused by surrounding or genetic factors only, and are not linked to the characteristics of sex. When analysing the differences between two groups (Group 1, comprising children who took part in an experiment that included participation in a physical therapy exercise programme twice a week for a period of six weeks, and Group 2, comprising children who took part in both an experiment that included participation in a physical therapy exercise programme twice a week for a period of six weeks, and a programme for the development of the speed of the psychomotor reactions), it was found that after six weeks the results of Group 2 were better. The results of the psychomotor reactions as measured before the experiment differed statistically insignificantly. To sum up, when applying physical therapy jointly with purposive exercises that develop the speed of psychomotor reactions, results can be achieved over the shortest period of time substantiated in scientific papers, i.e. six weeks.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the submission of this manuscript.

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