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INFLUENCE OF MOTIVATED WALKING WITH PARTIAL BODY WEIGHT SUPPORTING ON THE GROSS MOTOR FUNCTIONS IN CHILDREN WITH CEREBRAL PALSY

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Ключевые слова: *физическая терапия, мотивированная ходьба, частичная разгрузка веса тела, большие моторные функции*

Abstract. Influence of motivated walking with partial body weight supporting on the gross motor functions in children with cerebral palsy. Nekhanevych O.B., Bakuridze-Manina V.B., Smirnova O.L., Byoung-Yul. Y., Kosynskyi O.V. *The aim of the work is to increase the effectiveness of physical therapy of gross motor functions impairments in children with spastic cerebral palsy by using a therapeutic exercises program with partial body weight supporting and motivated walking on the device for the rehabilitation of people with impaired functions of the musculoskeletal system. The study included 30 children 6 to 11 years old with a spastic form of cerebral palsy. All patients were divided into 2 groups: in group I, in addition to the standard complex of physical therapy, walking according to the dynamic method was prescribed, in group II – according to the static method with partial body weight supporting. The duration of the program was 6 weeks. The survey was carried out before the start, at 2, 4 and 6 weeks of therapy. We studied the spatial-temporal characteristics of walking and activities of daily living indicators. The use of the developed program with the rehabilitation device positively influenced the spatial-temporal indicators of walking in both groups. The stride length, walking speed and the length of the covered distance has increased statistically significantly. A significant increase in the volume of performed activities of daily living in the first group was found. At the same time, an increase in this indicator was also observed in group II, but it did not reach statistical significance. The use of the developed program of therapeutic exercises, including walking with motivated movement and partial body weight supporting on the developed rehabilitation device positively influenced the static and dynamic characteristics of walking, which improved the performance of activities important for children with cerebral palsy, especially walking and running. The optimal time for increasing the length of one cycle of walking is a 4-week program, for the development of general endurance and speed – a 6-week program of therapeutic training.*

Реферат. Влияние мотивированной ходьбы с частичной разгрузкой веса тела на большие моторные функции у детей с церебральным параличем. Неханевич О.Б., Бакуридзе-Манина В.Б., Смирнова Е.Л., Бьон-Йоль Ю., Косинский А.В. *Цель работы – повысить эффективность физической терапии нарушений больших моторных функций у детей со спастической формой церебрального паралича путем применения программы терапевтических тренировок с частичной разгрузкой веса тела и мотивированным перемещением на разработанном устройстве для реабилитации людей с нарушениями функций опорно-двигательного аппарата. В исследование было включено 30 детей от 6 до 11 лет со спастической формой церебрального паралича. Все пациенты были разделены на 2 группы: в группе I дополнительно к стандартному комплексу физической терапии назначали ходьбу по динамической методике, в группе II – по статической методике с частичной разгрузкой веса тела. Длительность применения программы составила 6 недель. Обследование*

проводили до начала, на 2, 4 и 6 неделях тренировок. Изучали пространственно-временные характеристики ходьбы и показатели активности повседневной жизни. Применение разработанной программы с использованием реабилитационного устройства позитивно повлияло на пространственно-временные показатели ходьбы в обеих группах наблюдения. Статистически значимо увеличилась длина одного цикла ходьбы, скорость ходьбы и длина пройденной дистанции. Установлено значительный прирост объема выполненных активностей повседневной жизни в I группе наблюдения. При этом во II группе также наблюдалось увеличение данного показателя, но оно не достигло статистической значимости. Применение разработанной программы терапевтических упражнений, включающей выполнение ходьбы с мотивированным перемещением и парциальной разгрузкой веса тела на разработанном реабилитационном устройстве, позитивно повлияло на статико-динамические характеристики ходьбы, что улучшило выполнение важных для детей с церебральным параличом активностей, особенно ходьбы и бега. Оптимальными сроками для увеличения длины одного цикла ходьбы является 4-недельная программа, для развития общей выносливости и скорости – 6-недельная программа терапевтических тренировок.

In cerebral palsy (CP) one of the most difficult and common problems for physical therapy is to restrict patients from performing voluntary movements. This is associated with impaired motor function (muscle contractures, spasticity, decreased muscle strength, dystonia, discoordination and muscle weakness) [11]. Despite the non-progressive nature of neurological disorders in CP, without proper therapy there is an increase in the severity of motor disorders and as a consequence – the limitation of vital activity gradually progressively increases with age [14]. This significantly disrupts the daily activity of patients, in particular at the expense of the ability to move freely in space [7]. Especially important is the impairment of gross motor functions (ability to run, walk, stand, sit) [9].

The results of leading studies in recent years indicate that motor skills training does not occur while using traditional methods of rehabilitation based on the mechanical repetition of passive movements, [2]. Leading specialists pay special attention to the need to use as a therapeutic means of active performance of patient-specific tasks and activities, in particular in the usual conditions of the environment. This is the basis of neuroplasticity in the cerebral cortex [13]. In particular, training of functional walking to perform an important task for the patient is the key to successful acquisition of the necessary walking skills, it improves the spatio-temporal performance of walking and stereotype of walking, which increases its independence and degree of involvement in everyday life [15].

There is no consensus among experts on the need to use technical means for partial weight loss of the patient during training. Earlier works prove the effectiveness of such interventions [10]. However, the results of further studies indicate the lack of a positive effect on motor functions of partial support during training [12]. There are also works that emphasize the negative impact of rigid partial support on the ability to maintain balance while walking [16].

In the professional environment of specialists there are discussions about the type, frequency, intensity, duration of therapeutic interventions and the number of repetitions of exercises for the best mastering of the necessary motor skills. There is also no scientifically substantiated protocol of physiotherapeutic management of CP patients with static-dynamic disorders of walking [8].

Despite the achievements of modern medicine, one in three patients with CP is unable to walk [14]. This indicates the imperfection of modern approaches to the rehabilitation of such patients and requires generalization and the search for new methods of physical therapy.

The aim of the study was to increase the effectiveness of physical therapy of disorders of gross motor functions in children with spastic form of cerebral palsy by using a program of therapeutic training with partial weight loss and motivated movement on a developed device for rehabilitation of people with dysfunction of musculoskeletal system.

MATERIALS AND METHODS OF RESEARCH

The study involved 30 children aged 6 to 11 years (mean age was 8.6±1.3 years) with spastic diplegia due to CP, of which girls – 14 (46.7%) and boys – 16 (53.3%). According to the classification system of gross motor functions (GMFCS) [11], patients were distributed according to the severity of CP manifestations. Thus, 1 group of CP severity included 7 people (23.3%), 2 – 12 people (40.0%), up to 3-11 people (36.7%).

Criteria for inclusion in the study were age from 6 to 12 years, clinical form (bilateral spastic diplegia), severity of CP by GMFCS I-III degrees, the ability to stand independently, actively walk, the state of intellectual functions (ability to follow instructions), written consent to participate in the study. The exclusion criteria were: age up to 6 or more 12 years, significant visual disorders, history of epileptic seizures, surgery during the last

12 months, use of botulinum toxin A for the last 6 months, flexion contractures in the hip joint more than 30°, knee joint - more than 20 ° and ankle joint – more than 15°, others forms of CP.

Patients who participated in the study performed a standard set of physical therapy, which included passive and active exercises to increase the amplitude of movements in the joints, exercises to increase flexibility (postisometric relaxation), exercises to develop muscle strength of the torso and limbs, exercises for the development of balance on dynamic and static platforms, exercises for the development of coordination (in the sensory pool) and differentiated massage.

Randomization was performed using the STATISTICA 6.1 program, all patients were divided into two study groups. In addition to the standard rehabilitation program, all patients were prescribed therapeutic walking training using a device for rehabilitation of people with musculoskeletal disorders (Rehabilitation device) (Patent for invention 201 a201710595) [3]. The rehabilitation device comprises a foot platform installed between two horizontal supports, a vertical support stand with hand pillars, horizontal supports have front and back parts, equipped with wheels and connected by a perpendicular supporting frame. At the back of the frame there is a functional stand between the drive wheels which is connected with a headrest stand, a back with a lower and upper frame for placing the patient and an abductor-lift, which are installed with the ability to move and fix in a vertical plane. The functional stand contains a spring that is connected to the upper frame for placing the patient. The hand pillars are located in the front of the frame and are combined with a support stand and a crank mechanism with a foot platform and paired drive wheels. The front horizontal support has a control stand. The drive wheel has holes for adjusting the length and width of the patient's stride. Patients of the first group (n=14, mean age – 8.6±1.0 years) in addition to the standard complex of physical therapy were prescribed gait training using a Rehabilitation device according to the dynamic method (with motivated movement in the gym and partial unstable support of the pelvis with abductor-lift of the Rehabilitation device moving along the vertical axis). The latter included training once a day for 30 minutes: 5 minutes – preparatory part (performing passive and active exercises to increase the amplitude of movements), 20 min. – the main part (performing exercises on the Rehabilitation device in dynamic mode (with motivated movement), 5 min. – the final part (exercises for flexibility). Patients of the second group (n=16, average age – 8.6±1.5 years) in addition to the standard complex of physical therapy were prescribed gait training using the Rehabilitation device according to the static method (without movement) and with partial unloading of body weight at the expense of stable (fixed) support of the pelvis with abductor-lift of the Rehabilitation device. The duration of the developed physical therapy program was 6 weeks, the total number of trainings was 30. During the exercise on the Rehabilitation device stride frequency was selected taking into account the patient's comfort (at the level of 10-12 points by a subjective scale of loading (Borg scale)). The length and width of the stride were determined during the analysis of the spatio-temporal characteristics of the walking. Under conditions of increasing stride length and width set during the subsequent tests, at the 2nd and 4th weeks of the training program stride length and width on the Rehabilitation device were changed.

Examinations were performed before, at 2, 4 and 6 weeks of therapeutic training. Spatial-temporal indicators of walking (length of one cycle (LC) of walking, stride length) were studied by means of video recording and anthropometry with a centimeter tape, indicators of activity of daily life were investigated by the scale of measurement of gross motor functions (GMFM-66), the E scale was used to assess walking, running and jumping [6], functional walking performance was studied by standardized functional tests (walking speed (WS) was determined by a 10-meter walking test, endurance – by a 6-minute walking test) [5]. The STATISTICA licensed software package was used for statistical processing of the obtained data (6.1, serial number AGAR909E415822FA). The type of data distribution was determined using the W-test Shapiro-Wilk. Significance of differences between indicators was determined taking into account the type of distribution using Student's t-test, Mann-Whitney U-test and Pearson's chi-square test. ANOVA/MANOVA analysis of variance was performed to determine the influence of factors. The threshold level of statistical significance of the obtained results was chosen at $p<0.05$. The results are presented as M±m for quantitative indicators and as a percentage for qualitative indicators [1].

The study was conducted in accordance with the principles of the Helsinki Declaration of the World Medical Association "Ethical principles of medical research concerning human subjects" (amended in October 2013). Permission to conduct research was obtained by the Ethics Committee of the State Establishment "Dnipropetrovsk Medical Academy of Health Ministry of Ukraine". Written informed

consent was obtained from all parents of patients who participated in the study.

This work was performed in accordance with the research plan "Medical and pedagogical support of physical rehabilitation, sports and health training" (N of state registration 0116U004468, 2017-2021) of the Department of Physical Rehabilitation, Sports Medicine and Valeology of SE "DMA".

RESULTS AND DISCUSSION

The application of the developed technique with the use of the Rehabilitation device had a positive effect on the spatial-temporal indicators of walking in both groups of observation. Thus, the LC increased significantly from 64.6±4.0 cm to 73.1±4.1 cm in group I and from 68.0±4.1 cm to 75.9±3.9 cm in group II ($p<0.05$). At the same time, no statistically significant difference between I and II comparison groups in LC indicator was found at the end of the study (Table 1).

According to Table 1, there is a significant increase in LC in both observation groups in the first two weeks of training, with a relatively stable LC in the future. Thus, during the first two weeks of rehabilitation in group I there was an increase in LC by 6.57±0.42 cm, which was statistically significantly greater than the value of the growth of this indicator at 4 and 6 weeks of application of the developed program ($p<0.05$), where they were 1.21±0.09 cm and 0.65±0.06 cm, respectively. Similar changes were observed in the second group of observations, where after two weeks of rehabilitation l-C increased by 6.50±0.41 cm, while during subsequent observations at 4 and 6 weeks the dynamics was recorded at 0.56±0.05 cm and 0.81±0.07 cm, respectively.

Table 1

Dynamics of spatial-temporal indicators in the process of physical therapy (M±m)

Research phase		Length of cycle, cm		Walking speed, m/s	
		Group I	Group II	Group I	Group II
Screening		64.6±4.0	68.0±4.1	0.46±0.04	0.52±0.04
2 week	Abs.	71.2±4.2	74.5±4.0	0.50±0.05	0.55±0.04
	Δ	6.57±0.42	6.50±0.41	0.04±0.01	0.03±0.01
4 week	Abs.	72.4±4.1	75.1±4.0	0.53±0.05	0.59±0.04
	Δ	1.21±0.09	0.56±0.05	0.03±0.004	0.03±0.006
6 week	Abs.	73.1±4.1	75.9±3.9	0.62±0.05	0.63±0.04
	Δ	0.65±0.06	0.81±0.07	0.10±0.010	0.04±0.004*
	Δ total	8.43±0.56	7.88±0.35	0.16±0.01	0.11±0.01*

Notes: * – $p<0.05$ by the indicator between I and II groups of observation; Abs. – the absolute value of the indicator; Δ – the difference between the indicators in the corresponding week and the previous week of observation; Δ total – the difference between the indicators before and after the application of the program of therapeutic interventions; data are presented in M±m format.

The developed training program also had a positive effect on WS (Table 1). Thus, according to the 10-meter walking test, a statistically significant increase in WS was found both in the first observation group – by 34.8%, and in the second group – by 21.2% ($p<0.05$), in the absence of a difference between groups in absolute value. The analysis of growth dynamics revealed the largest increase in WS in the first group of observation from 5^{th} to 6^{th} weeks of training ($p<0.05$). Similar dynamics was observed in the second group of observations but the value of the increase in WS did not reach a statistically significant level ($p>0.05$).

In addition, during the application of the developed program of therapeutic interventions, an improvement in aerobic endurance was observed in both observation

groups (Table 2). The greatest increase in aerobic endurance was achieved in the last two weeks of training in both I and II groups ($p<0.05$). However, the increase in endurance in group I was statistically significantly greater than in group II ($p<0.05$).

Table 2

Dynamics of endurance indicators by a 6-minute walking test (M±m)

Research phase		6-minute walking test, m	
		Group I	Group II
Screening		216.7±23.3	231.1±21.2
2 week	Abs.	228.1±24.7	238.8±21.4
	Δ	11.4±3.7	7.6±1.1
4 week	Abs.	234.1±24.9	248.5±22.7
	Δ	6.1±1.2	9.8±3.0
6 week	Abs.	264.0±26.7	268.2±21.5
	Δ	29.9±3.1	19.7±2.7
	Δ total	47.3±4.2	37.1±3.1*

Notes: * – $p<0.05$ by the indicator between I and II groups of observation; Abs. - the absolute value of the indicator; Δ – the difference between the indicators in the corresponding week and the previous week of observation; Δ total – the difference between the indicators before and after the application of the program of therapeutic interventions; data are presented in M±m format.

Of particular interest are the data on the dynamics of gross motor functions by the scale GMFM-66 (Table 3). Thus, a significant increase in the percentage of functions performed in the first observation group was observed. At the same time, in group II there was also an increase in GMFM-66, but it did not become statistically significant. In a detailed analysis of the components of the increase, it was found that in the first group of observations it was statistically significantly better ($p<0.05$), therewith the largest increase was achieved in running and jumping indicators. In contrast, in the second group of observations the statistical significance occurred only in indicators that characterize the dynamics of walking.

The study confirmed the results of Verschuren O. et al., 2016 [14] on the positive therapeutic effect of functional walking on static-dynamic motor performance, including walking speed and length of one walking cycle and overall endurance in children with CP, at the same time they experienced the greatest dynamics during training with the use of motivated movement without stable fixation.

In contrast to the position of Willoughby KL, Dodd KJ, Shields NA, 2009 [16], which proved the negative impact of with training partial support, the results of this study show an improvement in both spatial-temporal walking and overall endurance during such trainings. However, it was therapeutic training without support that contributed to more positive changes, which confirms the data of Swe N.N. et al., 2015 [12].

Of particular attention are the data on the positive impact of cyclic therapeutic trainings without stable partial support on overall endurance, which, in our opinion, led to an increase in the percentage of performeding grosss motor functions in the group where the program of therapeutic training was used through motivated movement without stable fixation on the developed Rehabilitation device.

Table 3

Dynamics of indicators of gross motor functions on the GMFM-66 scale (E scale) (M±m)

Research phase		GMFM-66 (E scale),%	
		Group I	Group II
Screening		50.2±5.6	52.3±4.8
2 week	Abs.	53.7±5.6	53.1±4.8
	Δ	3.5±0.5	0.8±0.2*
4 week	Abs.	55.4±5.6	53.6±4.8
	Δ	1.7±0.2	0.5±0.1*
6 week	Abs.	56.6±5.6	54.1±4.8
	Δ	1.3±0.2	0.52±0.07*
	Δ general	6.4±0.6	1.8±0.2*

Notes: * – p<0.05 by the indicator between I and II groups of observation; Abs. - the absolute value of the indicator; Δ – the difference between the indicators in the corresponding week and the previous week of observation; Δ total – the difference between the indicators before and after the application of the program of therapeutic interventions; data are presented in M±SD format.

CONCLUSIONS

1. The application of the proposed program of therapeutic exercises which included walking with motivated movement and partial body weight supporting on the developed Rehabilitation device for persons with musculoskeletal disorders positively effected on the static and dynamic characteristics of walking. This improved performance of activities important for a child with cerebral palsy, including walking and running.

2. The optimal time to increase the length of one cycle of walking is a 4-week program, for the development of general endurance and speed – a 6-week program of therapeutic training. Implementation of this program using the developed Rehabilitation device for persons with musculoskeletal disorders with the possibility of moving and applying the technique of performing exercises with partial unstable pelvic support by an abductor-lift moving along the vertical axis, caused a positive effect on gross motor functions (walking, running and jumping) in children with spastic form of cerebral palsy.

Conflict of interest. The authors declare no conflict of interest.

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