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Physical therapy of static and dynamic motor disorders in children with hemiplegic cerebral palsy

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Abstract

Introduction. Regardless an improressive habit of neural disorders in cerebral palsy (CP), without a therapy the motor abnormalities' severity rising is registered and as a result with age the physical dysfunction progressively increases.

Purpose. To improve the static and dynamic motor disorders' and activity limitations physiotherapy efficiency among the children with hemiplegic CP form via the therapeutic training program on the developed device for rehabilitation of the people with muscle-skeleton disorder.

Material and methods. 24 children with unilateral CP aged from 6 to 11 were enrolled into the research. The patients were randomized into 2 groups. Additionally to the standard physiotherapy complex the I group were prescribed with the walking trainings on the rehabilitation device according to the dynamic method, the II group – according to the static method. Physiotherapy program duration was 6 weeks. The gait spatiotemporal characteristics and activity limitations were monitored.

Results. Applying developed program influenced on the walking spatiotemporal indexes in the both groups. The biggest increase of the distance and stride length were reached exactly on the 2 week. Herewith, distance incremental amount in the I group was higher than in the II study group. TUG test's time decreased statistically efficiently in the I group. Maximum TUG test's index depression was observed on the 6th study weeks. As a result GMFM-66 increased in I group.

Conclusions. An administration of the developed therapeutic program affected positively on the CP patients' spatiotemporal walking characteristics, balance and endurance, as a result, decreased the fall risk and activity limitations.

Key words: physical therapy; hemiplegic cerebral palsy; static and dynamic motor disorders.

Introduction

With all the varieties of cerebral palsy (CP) damages, one of the most common and difficult rehabilitation problems is patient limitation of voluntary movements which is driven by the motor functions abnormality (spasticity, dystonia, contractures, muscle weakness and incoordination) [Paulson A]. Regardless an improgressive habit of CP neural disorders, without a proper therapy the motor abnormalities' severity rising is registered and as a result with age the physical dysfunction progressively increases [13]. That significantly affects the patients' activities of daily living in particular due to the ability of free spatial movement [3]. Gross motor functions abnormality (ability of running, ambulation, standing, sitting) is especially important in this case [6].

The recent studies illustrate that the administration of the traditional approaches, based on the passive motion repeat, in these patients' treatment therapy does not let to the gain motion movements' skills [5]. Nowadays the lead specialists attract their attention to the therapeutic intervention which is focused on the active execution of the patient relevant specific tasks and activities especially in the habitual environment which is the basement of neuroplasticity (the positive changes in the cerebral cortex) [1]. For instance, functional walking training for the patient significant task performance is the key of the required walking skills' successful adoption, moreover it improves the spatiotemporal walking measures as well as the gate pattern, that increases his independence and the everyday life processes' attained involvement [15].

Also motor functions development approaches did not take into accounts the CP patients' inefficient progression of aerobic through the daily grand total movements'

limitation. The physical activity indices comparison of healthy children and the children with CP showed its measurements decrease for latters. The occasional information about spasticity increase among these patients was the reason to avoid the prescription of the exercises to progress aerobic endurance. According to the most researchers, exactly the physical activity limitation of the children with neurological disorders is the critical factor of the mobility progression negative influence and as the result it minimizes the vital activities [13].

Among the specialists there is no consensus on the administration necessity of the technology for the patient's partial weight support during trainings. The earlier works prove these interventions efficiency [7]. However the further research results demonstrate the absence of the positive influence on the fractional support motor functions during trainings [12]. Moreover there are works that insist on the hard fractional support negative influence on the ability to maintain equilibrium while walking [16].

Regardless the CP patients' therapy significant progress some scientists keep on discussions regarding the type, strength, duration, therapeutic exercises rate as well as the amount of repetition to gain necessary motor skills optimally. Also there is no entire scientific-based protocol on the therapeutic managing patients with static and dynamic ambulation disorders in CP [4; 10].

Regardless modern medicine achievements, one of three CP sufferers is incapable to walk [13]. That points at the inferiority of the existent therapy of such patients' rehabilitation and demands on the new physiotherapy methods generalization and search.

Purpose

To improve the static and dynamic motor disorders' and activity limitations physiotherapy efficiency among the children with hemiplegic CP form via the therapeutic training program on the developed device for rehabilitation of the people with muscle-skeleton disorder.

Material and methods

24 children (where girls and boys) with unilateral CP aged from 6 to 12 (the average age was 8.8 ± 1.4 years) were enrolled into the research. According to the gross motor function classification system (GMFCS) [9] the patients were randomized due to CP morbidity. Thus, the first CP morbidity group includes 5 individuals (20.8%), 11 people (41.7%) were randomized to the second group and the third group enlisted 8 patients (33.4%).

Entry criteria were age from 6 to 12 years, clinical pattern (unilateral CP), CP severity according to GMFCS I-III levels, ability to stand individually, active walking, intelligence functions condition (ability to follow the instructions), written inform consent. Exclusion

criteria were age less than 6 or more than 12, significant vision disorder, epileptic seizures in past medical history, surgical interference during the last 12 months, botulin toxin A administration during the last 6 months, hip joint flexion contraction more than 30°, knee joint flexion contraction more than 20°, ankle joint flexion contraction more than 15°, other CP forms.

All the study subjects were prescribed with the standard physiotherapy complex, which consisted of the exercises to increase range of motion, improve flexibility (postisometric relaxation), muscle-strengthening exercises for body and extremities, exercises to develop balance on the static as well as dynamic platforms, coordination exercises in the sensorial pools while playing and differentiated massage.

With the help of STATISTICA 6.1 program generated random numbers table, all the patients were randomized into 2 study groups. In concert with the standard rehabilitation program, all the patients were prescribed therapeutic walking training with the use of the “Device for rehabilitation of people with disabilities of the musculoskeletal system” (Rehabilitation device) [8]. The Rehabilitation device consists of the platform for legs which is installed between 2 lateral supports, vertical supporting pole with the hand holder, horizontal support poles that have front and back parts, equipped with the wheels which are connected to each other with the help of the perpendicular supporting frame when on its back side the functional support (located between coupled leading wheels) is installed, this functional support is attached to the vertical headrest support, the back with down and upper frames to dispose patients and to the abductor-lifts that allow to relocate as well as fix vertically in addition to this the functional support is fitted with the spring connected to the upper frame for patients’ allocation; the hand holders are placed on the base frame front side also linked to the support pole and crank-type mechanism with the platform for legs as well as coupled leading wheels, while the front horizontal support is equipped with the control console; besides the leading wheel is made with the holes to adjust the patient’s step length and width. Additionally to the standard physiotherapy complex the I group patients (n=12, the average age was 8.8 ± 1.4 years) were prescribed with the walking trainings on the Rehabilitation device according to the dynamic method (with motivated movement and transferring around a gym area and partial unstable hips’ support with the help of abductor-lift of the Rehabilitation device that moves along the vertical axis), that included 30 min duration trainings 1 times a day: 5 min is preparation period (passive and active exercises performing to enhance range of motion), 20 min is the main part (Rehabilitation device training in dynamic regime (with transferring and non-stable support by abductor-lift), 5 min is the final

period (flexibility and stretching exercises). Additionally to the standard physiotherapy complex the II group patients (n=12, the average age was 8.7 ± 1.3 years) were prescribed with the stepping trainings on the Rehabilitation machine according to the static method (without movement) and with fractional body weight relief by means of the stable (fastened) hips' support with the help of the Rehabilitation device abductor-lift. Therapeutic trainings were done once a day with 30 min duration. Physiotherapy program duration was 6 weeks; total amount of trainings during this period calculated 30 procedures. Step frequency while the treatment burden on the Rehabilitation device was selected due to the patient comfort feeling (at the rate 10-12 due to the individual physical activity scale of difficulty (Borg scale) [2]. Step length and width were indicated at the time of spatiotemporal ambulation characteristic analysis. Provided step length and width increase, which were indicated during the following tests, on the 2nd and 4th training weeks the step length and width on the Rehabilitation device were changed.

The examinations were done at the beginning of the study as well as on the 2nd, 4th, 6th weeks of the therapeutic trainings. The stepping spatiotemporal characteristics (step length, stride length, step width, walking rate) were monitored by filming and measuring tape anthropometry, daily routine vital activity index was monitored according to the gross motor function measure (GMFM-66) [11], and functional walking characteristics were studied by the use of the standard functional tests (walking speed was indicated in terms of "10 Meter walk Test" (10MWT), the endurance was monitored by the "6 Minute Walk Test (6MWT) [14], balance and falling risk were measured by "The Timed Up and Go test" (TUG test). The results of statistic data was processed by STATISTICA license program pack (6.1, number AGAR909E415822FA). The data distribution type was identified by Shapiro-Wilk's W-test. The accuracy of information between the indexes was specified in terms of the distribution type with the help of Student's t-test, Mann-Whitney U-test and Pearson's chi-squared test. ANOVA/MANOVA analysis was done to identify the factors 'effect. The statistical significance level threshold of the results was chosen $p < 0.05$. The results are given in the form $M \pm SD$ for quantity index and quality indicator was presented in the percentage.

The work was done in respect of the commission of medical ethics regulations, geared towards the instructions of Convention of the Council of Europe "About protection of human rights and dignity in terms of biomedicine" (1997) and World Medical Association's Declaration of Helsinki (2013). Written informed consent was obtained from all parents of patients who participated in the study.

Results

Applying developed methodology with the use of Rehabilitation device influenced on the walking spatiotemporal indexes in the both study groups (Tabl. 1). Thus, stride length increased statistically efficiently from 66.4 ± 13.2 m to 73.2 ± 15.6 m and in the II group it rose from 69.1 ± 14.3 m to 75.3 ± 15.7 m ($p < 0.05$). At the same time, no statistically significant difference between groups I and II of the comparison in terms of stride length at the end of the study was found. There was a significant increase in stride length in both observation groups in the first two weeks of training, with a relatively stable in the future.

Table 1. - The spatiotemporal characteristics of walking dynamic in the process of physical therapy

№	Investigation stage		Stride length, sm		Walking speed, m/s	
			I group	II group	I group	II group
1	Screening		66.4 ± 13.2	69.1 ± 14.3	0.45 ± 0.16	0.51 ± 0.15
2	2 week	Abs.	72.1 ± 18.5	73.9 ± 15.2	0.51 ± 0.19	0.54 ± 0.17
		Δ	6.7 ± 2.4	5.9 ± 1.1	0.05 ± 0.02	0.03 ± 0.02
3	4 week	Abs.	72.6 ± 14.4	74.9 ± 15.8	0.32 ± 0.17	0.58 ± 0.14
		Δ	1.11 ± 1.04	$0.50 \pm 0,64$	0.03 ± 0.03	0.03 ± 0.04
4	6 week	Abs.	73.2 ± 15.6	75.3 ± 15.7	0.63 ± 0.19	0.62 ± 0.15
		Δ	0.66 ± 1.01	$0.92 \pm 0,85$	0.10 ± 0.05	$0.03 \pm 0.02^*$
		Δ total	8.51 ± 2.15	7.32 ± 1.21	0.17 ± 0.06	$0.10 \pm 0.03^*$

Marks: * - $p < 0,05$ by indicators between I and II observation groups; 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 $M \pm SD$.

The developed training program also had a positive effect on the walking speed (Tabl. 1). Thus, according to the 10MWT, a statistically significant increase in walking speed was found both in the I (by 52.2%) and in II (by 21.2%) groups ($p < 0.05$), in the absence of a difference between groups in absolute terms. The analysis of growth dynamics revealed the largest increase in walking speed in the I group of observation from 5th to 6th weeks of training ($p < 0,05$). A similar dynamics was observed in the II group of observations, however, the majestic increase in walking speed did not reach a statistically significant level ($p > 0.05$).

The changes in measures of the endurance pattern attract attention (Tabl. 2). As a result, in comparison with the 2nd and 4th training weeks' indicators the biggest increase of the distance length, which was overcome by patients, reached exactly on the last training week in both study groups ($p<0,05$) and ranged 56.9 ± 17.1 m in the I group, while 39.2 ± 13.4 m in the II group. Herewith, distance incremental amount in the I group was higher than in the II study group ($p<0.05$).

Table 2. - The endurance dynamic by 6 MWT in the process of physical therapy

№ з/п	Investigation stage		6 MWT, m	
			I group	II group
1	Screening		210.5 ± 82.1	225.4 ± 80.1
2	2 week	Abs.	230.1 ± 91.5	230.1 ± 78.4
		Δ	12.9 ± 11.9	5.8 ± 3.9
3	4 week	Abs.	236.2 ± 98.1	249.1 ± 90.0
		Δ	6.0 ± 3.9	9.9 ± 13.6
4	6 week	Abs.	267.0 ± 100.1	263.1 ± 89.0
		Δ	32.9 ± 13.4	20.1 ± 11.2
		Δ total	56.9 ± 17.1	$39.2\pm 13.4^*$

Marks: * - $p<0,05$ by indicators between I and II observation groups; 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 $M\pm SD$.

TUG test's results are especially interesting due to the fact that, in comparison with the initial data, the standardized exercises doing time decreased statistically efficiently in the I group. Thus, at the end of the therapeutic program the duration of the given test execution was 20.2 ± 7.0 sec, which is on average 7.9 ± 3.2 sec less than at the beginning of trainings ($p<0,05$). On the other hand, TUG test execution time in the II group dropped only about 1.4 ± 1.4 sec that was statistically significantly less than in the I group and there was no difference with the beginning level. Maximum TUG test's index depression was observed on the 5th-6th study weeks.

Table 3. - The characteristics of TUG dynamic in the process of physical therapy

№ 3/II	Investigation stage		TUG, s	
			I group	II group
1	Screening		28.2±9.7	26.0±13.5
2	2 week	Abs.	26.5±9.6	25.5±12.1
		Δ	0.52±0.40	0.30±0.28
3	4 week	Abs.	24.6±7.9	25.0±12.1
		Δ	1.3±1.0	0.41±0.40
4	6 week	Abs.	20.2±7.0	23.8±11.7
		Δ	4.9±2.1	0,8±1,0*
		Δ total	7.9±3.2	1.4±1.4*

Marks: * - $p < 0,05$ by indicators between I and II observation groups; 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 $M \pm SD$.

Of particular interest are the data on the dynamics of gross motor functions on the GMFM-66 (E scale). Thus, there was a significant increase in the percentage of functions performed in the I group (6.4 ± 2.4 %). At the same time, in group II there was also an increase in GMFM-66, however, it did not become statistically significant (1.8 ± 0.9 %). In a detailed analysis of the components of growth, it was found that in the I group it was statistically significantly better ($p < 0.05$), with the largest increase was achieved in terms of running and jumping. In contrast, in the II group of observations, the statistical significance occurred only in terms of indicators that characterize the dynamics of walking.

Discussion

The study results approved the data of Verschuren O, et al., 2016 about the positive effect of the functional walking circular trainings on the spatiotemporal stepping indexes as well as general endurance index among children with CP, herewith they achieved efficient progress at the time of trainings with motivated movement without the rigid fixation.

Opposed to the opinion of Willoughby KL, Dodd KJ, Shields NA, 2009, who stood for the negative effect of the trainings with the fractional support, the given research results demonstrate improvement of the spatiotemporal as well as general endurance indexes while

these trainings. However exactly therapeutic trainings without support were instructional in more positive changes which is approved by Swe NN et al., 2015 data.

Special attention should be attracted to the information about the positive effect of the circular therapeutic trainings without stable fractional support on the equilibration and falling probability decrease indexes.

Conclusions

1. An administration of the developed therapeutic program with the use of the Rehabilitation device affected positively on the CP patients' spatiotemporal walking characteristics, balance and endurance.

2. One walking cycle length increase happens during the first 4 training weeks, endurance indexes demonstrated maximum dynamic only on the 6th week of training. This data can be used to schedule the rehabilitation plan to recuperate these abilities.

3. Development of the Rehabilitation device with an option of movement as well as administration of the exercising method with partial unstable hips' support with the abductor-lift that moves along the vertical axis affected positively on the equilibration index and decreased falling probability risk, as a result, decreased the fall risk and activity limitations.

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