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APPLICATION OF ROBOT-ASSISTED UPPER EXTREMITY TRAINING IN THE OCCUPATIONAL THERAPY TREATMENT OF CHILDREN WITH CEREBRAL PALSY

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Abstract. *In recent years, robotic neurorehabilitation has become a new modality in working with children with cerebral palsy (CP). The aim of the research is to show the application of robot assisted training (RAT) of upper extremities (UE) during occupational therapy (OT) treatment of children with CP. The research was conducted on a sample of 2 subjects (PS1 and PS2) diagnosed with CP. For the purposes of the research, we used observations and unstructured interviews, standardized tests MACS (Manual Ability Classification System), GMFCS (Gross Motor Functional Classification System), BI (Barthel Index), COPM (Canadian Occupational Performance Measure), BFMF (Bimanual Fine Motor Function) and objective measurement on Armeo®Spring Pediatric and GMS (gross motor strength). Therapeutic procedures were carried out through individual RAT program for UE and OT program to increase the level of independence and participation in activities of daily life with elements of Bobath concept. The results of A-ROM (Range of Motion) showed that PS1 and PS2 have better mobility in all segments of both UEs. A-MOVE (3D workspace) shows a larger range of motion in all three planes and better fluidity of motion, more to the left in PS1 and to the right in PS2. In both subjects, A-GOAL (Movement qualiti) verified improvement in coordination, shorter arm path ratio, less deviation and instability in the workspace. GMS value at PS1 (L-28/30 kg D-26/27 kg), PS2 (L-2.5/2.5 D-2/2.5 kg). BI values at PS1 initial (BI-93) and final (BI-93) and PS2 initial (BI-29) and final (BI-29) did not change significantly, neither GMFCS in PS1 (Level-I) and PS2 (Level -IV). The manipulative ability of both subjects remained unchanged. The change is significant in the average values of occupational performance (p=1.0) and satisfaction (p=1.2) in PS1 and performance (p=0.4) and satisfaction (p=0.6) in PS2. Conclusion: The results indicate that therapy on the Armeo®Spring Pediatric in combination with the Bobath concept in children with CP has a positive effect on improving the functional abilities of the UE.*

Key words: *cerebral palsy, occupational therapy, robot assisted training, Armeo®Spring Pediatric.*

Introduction

Children with developmental disabilities have reduced ability to acquire skills and roles, which stops them from developing a realistic image of their own capacities and knowledge, which are in fact their interests and values. In order to develop abilities that do not exist or exist in a remittent form, it is necessary to facilitate the development of abilities during occupational therapy treatment, therefore they need application of special methods, procedures, approaches and models. There are numerous methods and therapeutic procedures that are used in the process of training children with developmental disabilities in order to achieve a satisfactory level of independence and their full active inclusion in the society.

The beginning of the 90s of the 20th century was marked as the beginning of a new era of development of highly sophisticated, commercially available robotic devices for the rehabilitation of patients, applied at first for therapeutic purposes in order to improve motor recovery and better understanding of motor control. The first research on robotic rehabilitation for upper and lower extremities dates back to the end of the last century. Automated robotic devices for improving extremities motor skills are increasingly expanding [1]. Robotic neurorehabilitation is a new technology that provides high dose and intensity training and is increasingly used in the rehabilitation of patients with motor disorders deficit caused as a result of any neurological disease. Robotic assistance represents help with movement, provides additional afferent information and thus new motor activity, i.e. influence on neuroplasticity of the brain. Robotic devices can provide a greater dose of patient engagement during the repetition of various physical tasks compared to conventional therapy. Although the primary goal of robot-assisted training is to restore motor skills, secondary, the development of complications is prevented, because proper activation of the arm segments and hand avoids the shortening of muscles and ligaments and, consequently, prevents the development of joint contractures and spasticity. Timely feedback during exercise additionally motivates the patient and helps them improve their motor skills. Therapy is usually carried out by one therapist, who simply monitors and evaluates activity through special computer software that comes with device and allows the therapist to spend more time focus on patient's progress and therapy, reducing the need to provide direct physical assistance [2]. One such device is the Armeo ® Spring Pediatric, used together with a comprehensive neurodevelopmental concept in this research.

The goal of the research is to show the application of robotically assisted training of the upper extremities in the occupational therapy treatment of children with cerebral palsy.

Material and methods

The case study was conducted on a sample of 2 subjects (PS1 and PS2) with cerebral palsy, who were included in the program of habilitation, robot-assisted training of the upper extremities and treatment in occupational therapy. The research was conducted from November 2022 to February 2023 at the Institute for Physical Medicine, Rehabilitation and Orthopedic Surgery "Dr Miroslav Zotović", Banja Luka at the Department for Habilitation and Rehabilitation of Children and Youth with Locomotor Disorders. For the purposes of the research, the approval of the Institute for conducting the research was obtained, as well as the written consent of the parents for participation in the research. For the collection of basic data, the medical documentation of the Institute was used - medical history, occupational therapy record, occupational therapy assessment, targeted occupational therapy techniques, as well as the methods of direct observation and semi-structured interview. The data necessary for case presentations were obtained using standardized tests for occupational therapy assessment at Institute: MACS (*Manual Ability Classification System*), GMFCS **(***Gross Motor Functional Classification System***)**, BI (*Bartel Indxex*), COPM (*Canadian Occupational Performance Measure*), BFMF (*Bimanual Fine Motor Function*) [3], and objective by measuring on the device Armeo® Spring Pediatric and GMS (*gross motor strenght*) using the Saehan dynamometer. The subjects were included in a comprehensive habilitation treatment, and the occupational therapy program after the initial assessment included individual RAT (robot-assisted training) on the Armeo® Spring Pediatric (ASP) device and occupational therapy treatment according to the Bobath concept, after which the final assessment was carried out using the same measuring instruments.

Before starting therapy with the Armeo® Spring Pediatric device, it is necessary to adjust the device individually according to the patient. After the patient is correctly positioned and entered into the system (*name and surname, date of birth, sex, height, weight, weakened arm*), an initial assessment is made, which is carried out gradually, step by step, in order to avoid possible omissions. It consists of A-ROM (*Range of Motion*), A-MOVE (*3D workspace*) and A-GOAL (*Movement qualiti*) assessments. After completing the initial assessment, a therapy plan is determined. The order, weight and duration of each exercise is selected individually for each patient. Training must be focused on the patient's needs and abilities and must encourage their activity. The therapist can continuously adjust training parameters according to ability patient and according to the stage of recovery [2].

Case reports

Case Study 1

Basic anamnestic data

Boy (PS1), age 14, diagnosed G 80 (Paralysis cerebralis infantilis), G40 (Epilepsy), F 70 (Mild mental retardation). A child from another normal pregnancy, delivery after term completed naturally, PT 4450/54. The birth was difficult, born in

difficult asphyxiation, AS 1. Reanimated, then transferred to intensive care unit, where head ultrasound was performed - bilateral periventricular stronger hyperechoic hallo. Dg. R29 Neurological risk symptomatology. The first habilitation treatment at the Institute started at 1.5 months and has has regular check-ups with a physiatry specialist ever since and has been undergoing habilitation treatment on several occasions. Started walking at the age of 2.5. Kepra and Tegretol therapy was introduced at the age of ten due to an epileptic attack, and since then he has been under the constant supervision of a neuropediatrician. The last attack was a year ago. Magnetic resonance imaging revealed changes in the white matter of the semioval centrum, frontoparietal, supraventricular bilaterally, most likely of posthypoxic, postinflammatory etiology. He lives in a complete family with his parents and older sister on the ground floor of the family house in a rural area. Social and health care institutions are within a radius of 5 kilometers. He attends the 9th grade according to an adapted plan and program with a mild impairment of intellectual functioning, he is a very good student. His mother is his teaching assistant. The school is one kilometer away. The classroom is located on the first floor, he climbs the stairs independently, occasionally he holds on to the handrails. The interview with the boy and his mother gives the impression that family relations are harmonious and supportive.

Assessment in occupational therapy

During the assessment, the boy was communicative, motivated, kept his attention and concentration, cooperated through all activities in accordance with his abilities. He walks independently with modified scheme gait according to the principle of the paraparetic pattern. He is independent in transfers. He uses his hands with difficulty, through a changed pattern, in the function of grasping, communication, defensive and protective reactions. Left upper extremityis dominant. Coordination is rated as medium. During the activity, there are involuntary movements and tremors in the hands, more to the right. He has difficulties during adaptation, reaching, grasping (difficult and incomplete grasps) and release in both unilateral and bimanual activities. He writes with his right hand, with impaired graphomotor skills and often fails to complete the activity. He has adopted a routine pattern of performing self-care activities in which he is mostly independent, but he needs a little more time to perform them. From the point of view of productivity at school, he has difficulty writing and using geometric equipment, and therefore uses a laptop in class. Two years ago, until joining therapeutic procedures, he practiced football twice a week in a local club. In his spare time, he likes to draw on his laptop (sketches of cars and houses), watch TV and listen to music.
The results of specific tests are shown in Table 1 and the results of objective measurements on the Armeo ® Spring Pediatric device and the GMS hand are shown in Table 2.

Training plan and therapeutic goals in occupational therapy

Considering the boy's age and the demands of everyday life and at school, occupational therapy treatment was focused on: robot-assisted training, posture correction through all postural positions, improvement of coordination, relief of tremors, improvement of manipulative dexterity and speed, development of abilities and grasping skills, improving graphomotor skills, increasing bilateral manipulation and bilateral integration, and practicing self-care activities.

Techniques and activities in occupational therapy

Boy (PS1) is included in the habilitation treatment through the day hospital. He attended occupational therapy treatment regularly for 20 therapeutic days. Five times a week for RAT (robot-assisted training) on the Armeo® Spring Pediatric device for both upper extremities according to the schedule, each extremity alternately every other day for up to 30 minutes and for daily individual occupational therapy treatment according to the Bobath concept for one hour.

Before starting the therapy on the Armeo® Spring Pediatric device, the boy is properly placed in a sitting position on the chair. He maintains sitting position, with ergonomic adjustment. After the individual adjustment of the device, where the parameters for the length of the segments of the upper extremities as well as the level of optimal support were determined, an initial measurement was made and a therapy plan was made, where the number, order, weight and duration of the games were selected. Six games were selected for each hand, which were represented through all 3d planes: "BALLOONS" (2d-shoulder, elbow), "PIRATES" (2d-shoulder, elbow, hand grip), "FOLLOW THE FORM" (2d -shoulder, elbow), "AIR HOCKEY" (1 wrist), "HOCOKART" (1d-forearm) and "FRISBEE" (3d-shoulder, elbow, wrist). At the beginning of the treatment, the games were set for a shorter time, but as the training progressed, the time was extended to five minutes per game, i.e. up to 30 minutes of total time. The difficulty of the games is set to the middle of a total of three levels. Visual details are set to the highest of the three levels. The program was based on movement coordination and upper limb stability. The plan is set optimally according to the boy's capabilities in order to maintain motivation and avoid unwanted effects.

Individual treatment according to the Bobath concept was carried out immediately after the RAT for one hour, where previously set goals were worked on.

Reevaluation

During therapy at ASP, the boy was interested and motivated to complete the activities he started. With the ergonomic adjustment, he maintained the sitting position correctly and showed no signs of fatigue after 60 minutes, both during the RAT and during the Bobath concept individual treatment. After the end of the therapy, a final assessment was made using the same measuring instruments.

Table 1. Presentation of the initial and final measurement of the level of functional independence, gross motor strength, manipulative dexterity, bimanual dexterity and self-assessment of participation in daily activities life activities at PS1.

BI	93/100	93/100	Little addiction		
GMFCS	IV	IV			
MACS	Level-II/V	Level - II/V	Use the majority subject, but with some reduced quality and/or speed of success.		
BFMF	Level-IIb/V	Level-IIb/V	Both hands: limitations in more advanced fine motor skills.		
COPM	Performance		5.6	6.6	p=1.0
	Satisfaction		6.0	7.2	p=1.2

- the initial results measurements, *-the results of final measurements.*

BI (Bartel index), GMFCS (Gross Engine Functional Classification System), MACS (Manual Ability Classification System), BFMF (Bimanual Fine Motor Function) and COPM (Canadian Occupational Performance Measure)

In Table 1, we observe that the level of gross motor function and the degree of independence in performing daily activities did not change significantly, i.e., they remained at the same level. The improvement is visible in the problem areas identified by the boy based on COPM test, which shows us that the goals were set and achieved.

Table 2. Display of the results of GMS hand grip, range of motion and upper limb coordination on the Armeo® Spring Pediatric device at PS1.

GMS		L	28	30	p=2			18.6-42.6 kg				
		D	26	27	p=1			22.2-49.0 kg				
Armeo Spring		Support	Upper arm L 50%, D 60%				Forearm L 50%, D 60%					
A- ROM		Horizontal Abd. shoulders		Flexion shoulders		Internal/External rot. shoulders		Flex/ext elbow		Supination/ pronation		
	L	115°	135°	70°	88°	109°	115°	95°	97°	93°	118°	
	D	125°	136°	71°	88°	102°	105°	96°	97°	88°	106°	
A- MOVE	L	165140 cm3				290549 cm3						
	D	153212 cm3				242210 cm3						
A- GOAL		Ratio paths hand				Deviation cm			Instability cm			
	L	1.06		1.02		0.54	0.28		0.53	0.46		
	D	1.06		1.05		0.36	0.43		0.67	0.50		

- the initial results measurements, *-the results of final measurements.*

GMS (*rough motor strength***)** *–measurement forces fist grip using a manual hydraulic dynamometer* . **A-ROM** *- defines the range of motion in each joint separately.* **A-MOVE** *- assessment measures the combined movements of the patient's hand. It serves to set up the patient's workspace in two and three dimensions.* **The A-GOAL** *assessment measures: -* ***The***

hand path ratio *is the calculation of the path the patient traveled from the starting point to the destination point. -* ***The deviation*** *represents the average distance between the patient and the middle of the destination after reaching the destination. -* ***Instability*** *measures the deviation of the distance from the middle of the destination.*

In Table 2, the increase is evident in almost all objective measurement parameters after the final assessment.

Case study 2

Basic anamnestic data

Girl (PS2), age 6, with with a diagnosis of G80 (Paralysis cerebralis infantilis), G40 (Epilepsia), F 71 (Moderate mental retardation). A child from a second, controlled pregnancy. Delivery is completed in an emergency, naturally (bradycardia, umbilical cord wrapped around the neck and left shoulder, patchy placenta - umbilical thrombosis with placenta infarct). PT 3100/53, AS 3/4. The child was reanimated, ventilated, administered oxygen therapy, then transferred to the Center for Neonatology. Intensive diagnostics and treatment were carried out (Dg: Asphyxio neonatii, Convulsiones neonati, HIE II/III, Insuffitientio respiratoria). Under the control of a child neurologist, Eftil syrup was introduced. First hospitalization at the Institute at the age of 6, as an inpatient, due to evaluation for robot-assisted training on the Armeo® Spring Pediatric and Lokomat devices, and therapy according to the Bobath concept. Magnetic resonance findings indicate symmetrical damage in the frontoparietal white matter, PV and in the deep white matter, intra and peritalamic in terms of perinatal hypoxic-ischemic leukoencephalopathy. She lives with a complete family in an apartment on the 7th floor in the city center, with his parents, older sister and grandmother. She goes to kindergarten every day for 4 hours. She has an assistant. From the interview with her mother, one gets the impression that the parents are dedicated and caring in providing care and concern for the girl.

Assessment in occupational therapy

The girl comes to therapy accompanied by her mother. She uses a children's neurological wheelchair for motion. Eye contact is established. She understands simple verbal commands. She makes sounds and smiles spontaneously. She uses few words, speech is undeveloped. Sphincter control is established. Trunk control is poor. She uses pathological patterns of posture and movement, which are intensified in activity. Left upper extremity is dominant. Coordination is rated as medium. She has difficulties during adaptation, reaching, grasping (difficult and incomplete grasps) and release in both unilateral and bimanual activities. She picks up objects unsteadily and clumsy. When she moves left and right hand over the midline of the body, instability and leaning to the opposite side of the body is evident

During the day in the house, she prefers to spend time in the corner sofa and on the floor. Handrails are applied inside the living room and according to her mother, the girl moves independently on the floor and along the handrails. During the day, she

spends one hour in the walker-stand. She likes to play with a ball, with dolls, put puzzles together, play with her sister, go to the park on the slide and swing. The girl has not adopted a routine pattern in self-care activities. Her mother points out the problem with speech, personal hygiene activities, bathing and feeding as the biggest difficulty. The highest degree of involvement in self-care activities is shown by directing the gaze or extremity in the desired direction at the verbal allogation, and in the best case adding a part of the wardrobe or raising an arm or leg. In her place of residence, until she was involved in therapeutic procedures, she visited the Resource Center for Children and Youth twice a week, where she used the services of a physiotherapist, somatopedist, speech therapist and psychologist.
The results of specific tests are presented in Table 3 and the results of objective measurements on the Armeo® Spring Pediatric device and the GMS hand are shown in Table 4.

Plan training and therapeutic goals in occupational therapy

On the basis of the occupational therapy assessment and insight into the difficulties the girl has in activities of daily life and agreement with the mother, occupational therapy treatment was focused on robotics assisted training for upper extremities, training grips, inhibition pathological forms posture and movements and improvement postural control, increase range of motion in upper extremities, improvement of coordination and bilateral manipulation, stimulation of perceptive and cognitive abilities, stimulation of motivation, increase components of participation in self-care activities, assessment and correction of neurological stroller, training mothers therapeutic procedures.

Techniques and activities in working therapy

Girl is included in rehabilitation treatment as an inpatient accompanied by her mother. She attended occupational therapy treatment regularly for 20 therapeutic days. Six times a week at RAT on the Armeo® Spring Pediatric device for both upper extremities for up to 45 minutes and for individual treatment of occupational therapy by Bobath concept for one hour.
Before the beginning assessment and therapy on the device (ASP), additional ergonomic adjustment and positioning in the chair was necessary in order to obtain the most correct and stable position necessary for proper therapy. By applying the belt over the pelvis at an angle of 45° and placing a bench under the legs as well as an additional support for the opposite arm, a correct sitting position is achieved. After individual adjustment of the device, where the parameters for the length of the segments of the upper extremities are determined as well as level of optimal support, an initial measurement was made and a therapy plan was made where the number, order, difficulty and duration of the games were selected. Due to the different functional status of the left and right hands, different plans were made. For the left hand, six games were selected that were represented in the 1d and 2d planes: "BALLOONS" (2d-shoulder, elbow), "CLEAN THE OCEAN" (2d-shoulder, elbow),

"CLEANUP" (2d-frame, elbow, grip), "HIGH FLYER" (1d-shoulder), "GOAL KEEPER" (1d-forearm) and "RAIN MUG" (1d-shoulder). Three games in 1d and 2d planes were chosen for the right hand: "HIGH FLYER" (1d-shoulder) and: "BALLOONS" (2d-shoulder, elbow), "CLEAN THE OCEAN" (2d-shoulder, elbow). The girl spent up to 45 minutes every day in therapy for both upper extremities, 30 min for the left arm and up to 15 min for the right arm. Game difficulty and visual details are set to the easiest of the three levels. The plan is carefully set according to the girl's capabilities, in order to be as successful as possible answered the challenge while playing games. The game program was based on cognitive stimulation, increasing the range of motion, coordination of movements and stability of the upper limbs and trunk. The treatment was carried out under the constant supervision of an occupational therapist.

Individual Bobath concept treatment implemented for one hour daily. After RAT, it was necessary to make a certain time gap, so that the girl could rest and respond more adequately to the tasks in therapy. In therapy according to the Bobath concept, work was done towards previously set goals in agreement with the mother, and the ultimate goal was an increase in the component of participation in self-care activities and training of the mother in therapeutic procedures.

Reevaluation

During therapy on the ASP device, the girl was initially motivated and cooperated in all activities within the limits of her abilities. After half of the therapy days, the girl started to show signs of fatigue in therapy after 30 minutes, she lost motivation and attention both in the RAT and in the individual treatment according to the Bobath concept, and a correction of the plan was needed in the form of changing games, shortening the time duration, as well as verbal stimulation by the therapist. After the correction of the plan, the girl continued to play games, and the therapy was successfully completed. After the end of the therapy, a final assessment was made using the same measuring instruments.

Table 3. Presentation of the initial and final measurement of the level of functional independence, gross motor power, manipulative dexterity, bimanual dexterity and self-assessment of participation in everyday life in PS2.

BI	29/100	29/100	Heavy addiction		
GMFSC	V/V	V/V			
MACS	Level-IV/V	Level-IV/V	Uses a limited selection of simple items in tailored situations.		
BFMF	Level-IVb/V	Level-IVb/V	One hand: only catching. The other hand: only holding or worse tnen that		
COPM	Performance		4.6	5.0	p=0.4
	Satisfaction		6.4	7.0	p=0.6

- the initial results measurements, -the results of final measurements.

Functional Classification System), MACS (Manual Ability Classification System), BFMF (Bimanual Fine Motor Function) and COPM (Canadian Occupational Performance Measure)

Looking at Table 3, we observe that the level of gross motor function and the degree of independence in performing daily activities did not change significantly, i.e. they remained at the same level. In the problem areas identified by the mother, based on the COPM test, change was detected in the form of improvements in performance and satisfaction.

Table 4. Display results GMS - grip strenght, volume movement and upper extremity coordination on the Armeo® Spring Pediatric device at PS2.

GMS		L	2.5		p=0		7.3-16.3 kg				
		D	2		p=0.5		9.1-17.7 kg				
Armeo Spring		Support	Upper arm L 50%, D 60%				Forearm L 50%, D 60%				
A- ROM		Horizontal Abd. shoulders		Flexion shoulders		Internal/External rot.shoulders		Flex/ext elbow		Supination/ pronation	
		86°				81°	87°				
		71°				73°	96°				
A- MOVE		43841.5 cm3				66186.5 cm3					
		63458.2 cm3				111923.0 cm3					
A- GOAL		Ratio paths hand				Deviation cm		Instability cm			
		1.43		2.61		0.54	0.29	0.60		0.74	
		1.16		1.55		0.79	0.37	0.84		0.65	

-the results of initial measurements, - the results of final measurements.

GMS (rough motor strength) – power measurement fist grip using a manual hydraulic dynamometer. A-ROM - defines the range of motion in each joint separately. A-MOVE - assessment measures the combined movements of the patient's hand. It serves to set up the patient's workspace in two and three dimensions. The A-GOAL assessment measures: - The hand path ratio is the calculation of the path the patient traveled from the starting point to the destination point. - The deviation represents the average distance between the patient and the middle of the destination after reaching the destination. - Instability measures the deviation of the distance from the middle of the destination.

In Table 4 and comparing the results of the initial and final assessment of the objective measurement, we see that the GMS remained unchanged in the left upper extremity, while a slight improvement was noted in the right, but they still remained below the average reference values. The analysis of objective measurement data on the Armeo® Spring Pediatric device shows that the results are better in both upper extremities, slightly more in the left.

Discussion

There are numerous methods and therapeutic procedures that are used in the process of training children with cerebral palsy, but there is no official evidence which therapy is the most effective in order to achieve a satisfactory level of children's independence and their full active inclusion in the social community. Considering that robotic rehabilitation belongs to a new and insufficiently researched area in medicine, the number of researches in this area is continuously increasing, and there is more and more scientific evidence of its effectiveness [4]. The goal of the research was to show the application of robotically assisted training (RAT) of the upper extremities during the occupational therapy treatment of children with cerebral palsy. In order to explain the sample of two respondents, the discussion will be conducted through the presentation of interpersonal similarities between the respondents (PS1 and PS2) regarding etiological factors, associated medical and functional difficulties i.e, habilitation treatment, outcome of RAT of the upper extremities, manipulative dexterity and degree of participation in activities of daily life. We observe both respondents and see that they are of different gender and age, PS1 14 years old and PS2 7 years old. Both subjects were born naturally, subject PS1 a little after the due date, and subject PS2 a little before the due date. It is evident that both subjects had severe asphyxia and hypoxia, which was stated by the author Mejaški (2007) in her work as one of the frequent causative factors of the occurrence of cerebral palsy [5]. In both subjects, the MR findings show ischemic changes in the white matter in terms of perinatal hypoxic - ischemic leukoencephalopathy. Habilitation treatment for both subjects was started in the first trimester of life. The author Savić (1992) points out that early recognition and inclusion in habilitation/rehabilitation treatment is one of the principles in the treatment of children with cerebral palsy, which significantly increases the possibility of comprehensive progress [6]. In both subjects, there are several associated disorders: epilepsy, mental retardation, sensorimotor disorders, developmental disorders, perceptual-cognitive disorders, social and functional problems in everyday life, deformities of the locomotor system, as stated by the author Savić (1992) [6]. The subject (PS1) performed the habilitation treatment as a day hospital patient accompanied by his mother, while the subject (PS2) performed the habilitation treatment as an inpatient accompanied by his mother. Since progress in therapy is evident in both subjects, it can be concluded that the role of the mother is of special importance, regardless of the calendar age. Both respondents live in complete families, respondent PS1 in house in rural area, while respondent PS2 lives in an apartment in urban area. Based on the interviews, it can be concluded that the relationships in both families are harmonious and supportive, and that the parents are

caring and dedicated in providing care for the children. The support of the family is extremely important for supporting the development of the child. As the author Savić (1992) states, the parent and the child occupy a central place in the rehabilitation team. Although they, unlike other team members, are the only ones that are not professionally educated, parents have a specific task [6]. PS1 is a regular elementary school student, PS2 uses the services of pre - school upbringing and education. Both respondents have an assistant. The author Kraguljac (2018) points out that in Croatia there is currently prevailing trend of including children with disabilities in regular classes as much as possible. Inclusion in regular classes brings a positive psychosocial aspect of schooling and increases academic expectations from students with disabilities [7]. This approach to children with disabilities prevails in the Republic of Srpska and Montenegro, both in school and pre - school institutions, which is evident in both respondents. Subject PS1 has functionally better gross motor functions, walks independently, has better manipulative abilities, better perceptual-cognitive abilities, has adopted a routine pattern in self-care activities in which he is independent in most activities, while subject PS2 uses a wheelchair for motion, uses a gesture for communication and is completely dependent on the help of another person. Subject PS1 needed minimal adjustment of the sitting position during therapy, while subject PS2 needed significant support with aids, in order to ensure the minimum conditions for conducting therapy. Automatic postural adjustment, as indicated by the authors Klaić and Milaščević (2007), is necessary for selective control and coordination of movements, its deviation has huge consequences on the child's functional status, which is the case with PS1 and PS2. Since daily activities require constant adaptability of the muscular activity of the trunk and pelvis, PS2 does not have the corresponding automatic postural adaptability and performs functional activities through numerous movement compensations and with much more expended energy [8]. Due to the heterogeneity of therapeutic goals and study methodology, there is no clearly defined therapy protocol. Various protocols have been described that include the duration of individual training from 25 to 60 minutes, 2-5 times a week, and all total duration from 2-12 weeks [9-12]. The subjects in this study had different therapeutic protocols. Subject PS1 had a program of up to 30 minutes, on the ASP device for upper extremities alternately every other day and one hour of therapy according to the Bobath concept five times a week and a total duration of 20 days. Subject PS2 had a daily program for both upper extremities of up to 45 minutes on the ASP device and one hour Bobath concept therapy, six times a week and a total duration of 20 days. PS1 did not show signs of fatigue or loss of motivation during the entire duration of the therapy, while PS2 after a certain time began to show signs of fatigue, loss of attention and motivation, and additional encouragement from the therapist was needed. As the author Horvatić (2009) points out, the loss of motivation is a person's inability to formulate goals and initiate actions, which was a difficulty with PS2 during treatment. Without an external stimulus, the PS2 could not function in a way that used the minimum capacity. It is important that people with brain damage face and learn to deal with problems of motivation and depression. They should be encouraged to face different challenges and especially appreciate every success, which is also motivation [13]. Several studies have shown a positive effect of robotic therapy on functional improvements in coordination and fluidity of

upper limb movements [14-18]. In our study, in both subjects, improvement was evident in the range of motion in all segments of the upper extremities, an increase in the range of motion of the upper extremities through all 3D planes, better fluency of movement and coordination, and hand grip strength. According to three studies, an increased effect on the facilitation of active participation was observed through augmented feedback using video games with virtual reality, which additionally motivated children to increase their response to different degrees of difficulty during robot-assisted training, which was the case and at PS1 [10,18,19]. After the therapeutic procedures, there were no significant changes in the subjects' independence in performing everyday life skills. Subjectively, both respondents stated that there was an improvement both in individual functional abilities and skills, as well as in individual segments of daily life activities, which was verified by the improvement in the average performance of the occupation. and satisfaction in both subjects. By mutual comparison, PS1 identified three goals from the self-care domain (dressing, putting on deeper shoes, buttoning and zipping), and two goals belonged to the productivity area (writing and using a ruler). The goals of PS2 were focused on the problem area from the domain of self-care (dressing, bathing, personal hygiene, feeding and drinking). Dependency in performing self-care activities in PS1 was minimal, while PS2 classified the subject in the category of severe addiction, and facilitating participation in purposeful targeted activities was the main focus during occupational therapy treatment. Applying a client-oriented approach based on the Bobath concept and RAT in a virtual environment, the functional capacities of the upper extremities are developed for the child in a fun and motivating way, which are necessary for easier participation and performance of everyday life activities.

Conclusion

The use of robotics in the occupational therapy treatment of patients with neurological diseases opens up new possibilities in the rehabilitation of children with cerebral palsy and raises its quality to a higher level, but also serves as an additional modality to some of the therapeutic approaches and methods. Some of the advantages of robot - assisted training are: repetition, which is very important for motor learning; motivation, which is key to progress and is sustained through interesting content and quality feedback in real time. Based on the knowledge and results obtained through research, the fact is confirmed that cerebral palsy is a permanent disorder of posture and movement, which affects the health status of the child, as well as general functioning in everyday life and the training process is long-lasting. For this reason, it is extremely important to start the habilitation treatment as early as possible, to include all members of the multidisciplinary habilitation team, so that the child with cerebral palsy achieves the greatest degree of independence. Team members participating in the habilitation and rehabilitation of children with cerebral palsy are: physiatrist, physiotherapist, occupational therapist, speech therapist, psychologist, defectologist, social worker, nurse, orthotist and teacher-pedagogue. If necessary, other specialists such as neuropediatrician, orthopedist, ophthalmologist,

neurosurgeon, etc. are involved. The role of parents is very important and therefore it is necessary to educate them with stimulating methods/procedures, with the aim of intensive and continuous implementation of therapeutic procedures in home conditions for the quality of the final training results. Also, every child with cerebral palsy should be given the opportunity to integrate into educational institutions, because the benefits of inclusive education are indisputable. A functional training plan should be created specifically for each child. An individual approach is important, because there are no two identical children with the same clinical picture and pathophysiological background. Such an approach enables flexibility and individualization in order to achieve the goals set for the child and the family. Based on the research results, we can conclude that the application of robot-assisted training on the Armeo Spring Pediatric device, in combination with therapy according to the Bobath concept, in children with cerebral palsy has a positive effect on improving the functional abilities of the upper extremities, perceptive and cognitive abilities and motivation, and thus also to increase the degree of participation in daily life activities that include the sector of self-care, productivity and leisure.

References

[1] Schmidt H, Hesse S, Warner C, Bardeleben A. Upper and lower extremity robotic devices to promote motor recovery after stroke-recent developments. In: The 26th Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE, 2004, San Francisco, California, p. 4825-4828.

[2] User manual, Armeo® Spring Pediatric; Hocoma AG, Industriestrsse 4, CH-8604 Volketswil, Switzerland; Last revision: 2018-11-27; AO-PE-UM2.2- hr-20181127; Document catalog number: 33319.

[3] Bartolac A. Assessment methods in occupational therapy: 2016.

[4] Borggraefe I, Klaiber M, Schuler T, Warken B, Schroeder SA, Heinen F et al. Safety of robotic- assisted treadmill therapy in children and adoles- cents with gait impairment: A bi-centre survey. Dev Neurorehabil. 2010; 13: 114-9.

[5] Mejaški-Bošnjak V. Neurological syndromes of infancy and cerebral palsy. Pediatrica Croatia 2007; 51: 120-9.

[6] Savić K. Basics of children's habilitation and rehabilitation: Novi Sad. Faculty of Medicine, University of Novi Sad. in 1992.

[7] Kraguljac D, BrenčićM, ZibarT and Schnurrer Luke-Vrbanić T. Habilitation of children with cerebral palsy. Medicina Fluminensis: Medicina Fluminensis 2018; 54(1): 6-17.

[8] Klaić I, Milaščević D. The influence of physical activity on various determinants of health-related fitness in children and adults with cerebral palsy. Croatian sports medicine journal, 2007, 22.2: 63-70.

[9]Drużbicki M, Rusek W, Snela S, Dudek J, Szczepanik M, Zak E, Sobota G. Functional effects of robotic-assisted locomotor treadmill thearapy in children with cerebral palsy. Journal of rehabilitation medicine, 2013, 45.4: 358-363.

[10] Borggraefe I, Kiwull L, Schaefer JS, Koerte I, Blaschek A, Meyer-Heim A et al. Sustainabili- oty of motor performance after robotic-assisted treadmill therapy in children: an open, non-ran- domized baseline-treatment study. Eur J Phys Rehabil Med. 2010; 46: 125-31.

[11] El-Shamy SM. Efficacy of Armeo® Robotic Therapy Versus Conventional Therapy on Upper Limb Function in Children With Hemiplegic Ce- rebral Palsy. Am J Phys Med Rehabil. 2018; 97 (3): 164-9.
[12] Gilliaux M, Renders A, Dispa D, Holvoet D, Sapin J, Dehez B, Detrembleur C, Lejeune TM, Stoquart G. Upper limb robot-assisted therapy in cerebral palsy: a single-blind randomized con- trolled trial. Neurorehabil Neural Repair. 2015; 29 (2): 183-92.
[13] Horvatić J, Joković Oreb I, and PinjatelaR. Damage to the central nervous system. Croatian Review of Rehabilitation Research 2009; 45(1): 99-110.
[14] Ladenheim B, Altenburger P, Cardinal R et al. The effect of random or sequential presentation oftargets during robot-assisted therapy on children. NeuroRehabilitation. 2013; 33 (1): 25-31.
[15] Fluet GG, Qiu Q, Kelly D et al. Interfacing ahaptic robotic system with complex virtual environments to treat impaired upper extremity motor function in children with cerebral palsy. Developmental Neurorehabilitation. 2010; 13 (5): 335-45.
[16] Turconi AC, Biffi E, Maghini C, Peri E, Servodio Iammarone F, Gagliardi C. May new technologi- es improve upper limb performance in grown up diplegic children? European Journal of Physical and Rehabilitation Medicine. 2016; 52 (5): 672-81.
[17] Smania N, Bonetti P, Gandolfi M, Cosentino A, Waldner A, Hesse S et al. Improved gait after re- petitive locomotor training in children with ce- rebral palsy. Am J Phys Med Rehabil. 2011; 90 (2): 137-49.
[18] Druzbicki M, Rusek W, Szczepanik M, Dudek J, Snela S. Assessment of the impact of orthotic gait training on balance in children with cerebral palsy. Acta Bioeng Biomech. 2010; 12: 53-8.
[19] Koenig A, Wellner M, Köneke S, Meyer-Heim A, Lünenburger L, Riener R. Virtual gait trainingfor children with cerebral palsy using the Loko- mat gait orthosis. Stud Health Technol Inform. 2008; 132: 204-9.

PRIMJENA ROBOTSKI ASISTIRANOG TRENINGA GORNJIH EKSTREMITETA U RADNOTERAPIJSKOM TRETMANU DJECE SA CEREBRALNOM PARALIZOM

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Sažetak. *Posljednjih godina robotska neurorehabilitacija postaje novi modalitet u radu sa djecom sa cerebralnom paralizom (CP). Cilj istraživanja je prikazati primjenu robotski asistiranog treninga (RAT) gornjih ekstremiteta (GE) tokom radnoterapijskog tretmana djece sa CP. Materijal i metode: Istraživanje je provedeno na uzorku od 2 ispitanika (PS1 i PS2) sa dijagnozom CP. Za potrebe istraživanja koristili smo metod opservacija i nestrukturirani intervju, kao i standardizovane testove MACS (Manual Ability Classification System), GMFCS (Gross Motor Functional Classification System), BI (Bartel Index), COPM (Canadian Occupational Performance Measure), BFMF (Bimanuelna fina motorna funkcija), te objektivno mjerenje na uredjaju Armeo®Spring Pediatric i GMS (gruba motorna snaga). Terapijski postupci su provedeni kroz individualni program RAT za gornje ekstremitete i program radne terapije za povećanje stepena samostalnosti i učestvovanja u aktivnostima svakodnevnog života sa elementima Bobath koncepta. Rezultati A-ROM (Range of Motion) projekcije su pokazali da PS1 i PS2 imaju bolju pokretljivost u svim segmentima oba gornja ekstremiteta. A-MOVE (3D workspace) je sa većim obimom putanje u sve tri ravni i boljom fluidnosti pokreta, više lijevo kod PS1, a desno kod PS2. Kod oba ispitanika A-GOAL (Movement qualiti) prikaz je verifikovao poboljšanje koordinacije, kraći omjer putanje ruke, manje odstupanje i nestabilnost u radnom prostoru. Vrijednost GMS kod PS1 (L-28/30 kg, D-26/27 kg), PS2 (L-2,5/2,5 D-2/2,5 kg). Vrijednosti BI kod PS1 inicijalni (BI-93) i finalni (BI-93) i PS2 inicijalni (BI-29) i finalni (BI-29), se nisu značajno promijenile kao i GMFCS kod PS1 (Nivo-I) i PS2 (Nivo-IV). Manipulativna sposobnost kod oba ispitanika je ostala nepromijenjena. Promjena je značajna u prosječnim vrijednostima okupacija PS1 izvođenje (p=1,0) i zadovoljstvo (p=1,2) i PS2 izvođenje (p=0,4) i zadovoljstvo (p=0,6). Zaključak: rezultati ukazuju da terapija na uređaju Armeo® Spring Pediatric u kombinaciji sa terapijom po Bobath konceptu kod djece sa cerebralnom paralizom ima pozitivan učinak na poboljšanje funkcionalnih sposobnosti GE.*

Ključne riječi*: cerebralna paraliza, radna terapija, robotski asistiran trening, Armeo® Spring Pediatric*