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Re-Education Movements of the Paretic Upper Extremity in Children age by Using Non-robotic Equipment

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Abstract

Background: Pilot study tested re-education movements of upper extremity in children with hemiparesis syndrome and this study determined the effect of therapy on Armeo® equipment on movement and the ability to grip of upper extremity**.**

Methods: This Investigation consisted of twenty-three children with impaired upper extremity. They had twenty therapies in Armeo® equipment.

Results: After rehabilitation by equipment Armeo® the children achieved greater range of motions in the upper extremity which resulted in a higher average output score than the input score. Significant better results demonstrate the improvement in hand grip which resulted in higher average output score compared with the input score.

Conclusion: By the therapy in Armeo® equipment were achieved statistically significant results in improving manual activities of upper extremity, improvement the range of motions and also improvement of grip of paretic hand.

Keywords: equipment, cerebral palsy, non-robotic, therapy, children, patient**,** neurological disorders.

Introduction

Pilot studies have tested improvements of upper extremity movements in children with hemiparesis syndrome. Functional limitations in mobility of hemiparesis have severely limit the patient's activity in all areas of life. Reasons for the development of hemiparesis may be various. Hemiparesis is most frequently caused by the development of cerebral palsy, stroke, brain injury, spinal cord injury, multiple sclerosis or brain and spinal tumors[1].

Cerebral palsy (CP) is defined as a group of permanent disorders of movement and posture, causing activity limitations attributed to a static lesion in the developing brain, often accompanied by secondary impairments. Predominant clinical manifestations found in - CP includes: weakness, loss of selective motor control, spasticity, and antagonist contraction. Significant impairments caused by this disorder may compromise motor function, and as a result, individuals with CP experience functional limitations that affect activities of daily life ranging from mild incoordination to total body involvement[2]. Children and adolescents with CP have decreased levels of physical activity compared with their peers without CP. The ability to sustain physical activity at the intensity and duration necessary for participation is an important outcome of intervention. Young children with CP may be at risk for reduced physical activity and/or ability to sustain physical activity secondary to impairments in muscle performance, limitations in mobility, high calorie demands for growth, and decreased aerobic capacity[3]. Spasticity as a major part of the damage to the central nervous system reduces the patient's mobility, self-sufficiency and ultimately the quality of life. Spasticity significantly reduces motor skills in patients with minimal palsy and a predisposition for the origin of contractures[1].

During the first year of life, infants develop rapidly and acquire the ability to actively explore and act on their environments. Researchers, who have studied the effects of self-produced locomotion (eg, crawling or walking) in children’s development. They typically, view it as standard psychological changes in infants and developmental changes in social understanding, spatial cognition and communication[4]. Focused development of kinesiology for the first 12 to 18 months after the birth, it is a considerable support to the study of treatment and movement disorders. Motor development obviously has been in progress during intrauterine life and it continues also after the 18-th month. This can also continue throughout the whole childhood and in some cases entire life. Tonic and phasic muscles respond within the motor program as functional units and are linked reflexively. The weakening later muscle automatically causes changes to the join position and also occurs to the reflection feedback of the lack of response to all motor child´s skills[5]. Hemiparesis is usually a lifelong health problem, but is not unsolvable. By the effort to stifle debilitating disorder in hemiparesis and to therefore prevent its progression, it needs to be followed by restoration of lost functions and paretic upper extremity which have created different methodological techniques and concepts. These are mostly based on the neurophysiologic basis[6]. New therapeutic options are still currently created and strive to positively influence the paretic upper extremity mobility. That is why we decided to devote new medical-technical options that affect the function of the upper extremity of a patient with cerebral palsy. The central nervous system is kept informed of the activities of the muscles and changes the length of so-called proprioceptors, which is located in the muscles and tendons[7].

The therapy was implemented by means of equipment Armeo®. The Armeo® equipment is an arm orthosis equipped with various components, including a pressure-sensitive handgrip. A spring mechanism provides adjustable weight support for the arm requiring treatment which also facilitates functional arm movement. The Armeo® is used to support functional therapy for patients who lose function in their upper extremity caused by cerebral, neurogenic, spinal, muscular or bone-related disorders. The Armeo® is based on the product T-WREX`. It is a passive (non-robotic) upper extremity orthosis, which lightens the weight of the upper extremity in 3D space. It allows natural movement in the workspace of approximately 66% of normal working area in the vertical and 72% in the horizontal plane. It allows quantifying range of motion and gripping strength in the patient's interaction with the software during therapy. This facilitates for users with moderate to severe hemiparesis to achieve greater range of motion than is possible without derating weight of the upper extremity. It also allows use of upper extremity targeted and coordinated, although it retained residual possibility of movement. Since this is non-robotic, equipment requires the initiation of patient motion, which requires the active participation of the patient during training[8] (Figure 1).

Figure 1. Training in 3D workspace

The purpose of this study was to determine the effect of therapy in the system Armeo® and on the movements and the grip´s of the ability of upper extremity in children with hemiparesis syndrome. In a pilot study, we sought to identify and verify the extent to which Armeo® equipment can effect the functionality of self-sufficiency and improve paretic of upper extremity in children with hemiparesis syndrome. Even though we know that the complete elimination of hemiparesis is impossible, we believe that hemiparesis upper extremity can effect to a large extent, so much so that children can improve their independence and quality of life.

Methods

The object of investigation consisted of twenty-three children, 10 to 16 years old with impaired upper extremity. They all have taken twenty therapies in Armeo® system. One therapy lasted 45 minutes of active exercise and frequency was minimal to twice a week. We mention the first results of tested children by using Armeo® device for the period of 2012-2014. We realized that following these studies, we required more children and further investigation that will be depended on the homogeneity of the children. Classifying criteria for the therapy by Armeo® equipment were: diagnosis of CP - hemiparesis according International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10) G 80.2, child and adolescent age, the ability to self-sustaining seating with leaned back lower extremities and the opportunity to cooperate. The children with severe cerebral palsy were not integrated, uncooperative patients with severe cognitive deficits, inability to properly set up the patient to the Armeo® equipment and early discontinuation of treatment. Children were tested before and after completion of therapy using goniometric investigation[9] and by testing grip of paretic's hand (cylindrical, spherical, lateral, hook...)[9].

For processing the collected data was chosen a numerical evaluation and statistical methods.

It was used a descriptive analysis, Student's paired dependent t-test and Wilcoxon Signed Ranks Test. Student's paired dependent t-test was used to evaluate the range of motion of the upper extremity for shoulder flexion and wrist flexion only. This test investigates the differences of two quantitative variables in the same investigating population. The result of the test is the *t* value (positive or negative), and significance. If the significance of the test is on the value *a* higher than

0.05, then our observation of an intervention is not random. For other ranges of motion of the upper extremity and for evaluating the hand grip was used the Wilcoxon Signed Ranks Test - nonparametric statistical test, because in comparing to the test of the range of motion didn't work the test of normality for variances. This test does not compare the obtained values, but order of assigned values from the smallest to the largest. Data were processed by using the software Microsoft Office Word 2007, Microsoft Office Excel, 2007. For mathematical - statistical evaluation was used descriptive statistical methods SPSS 16.0. The study was conducted in accordance with ethical principles, based on the Declaration of Helsinki (1964)[10].

Results

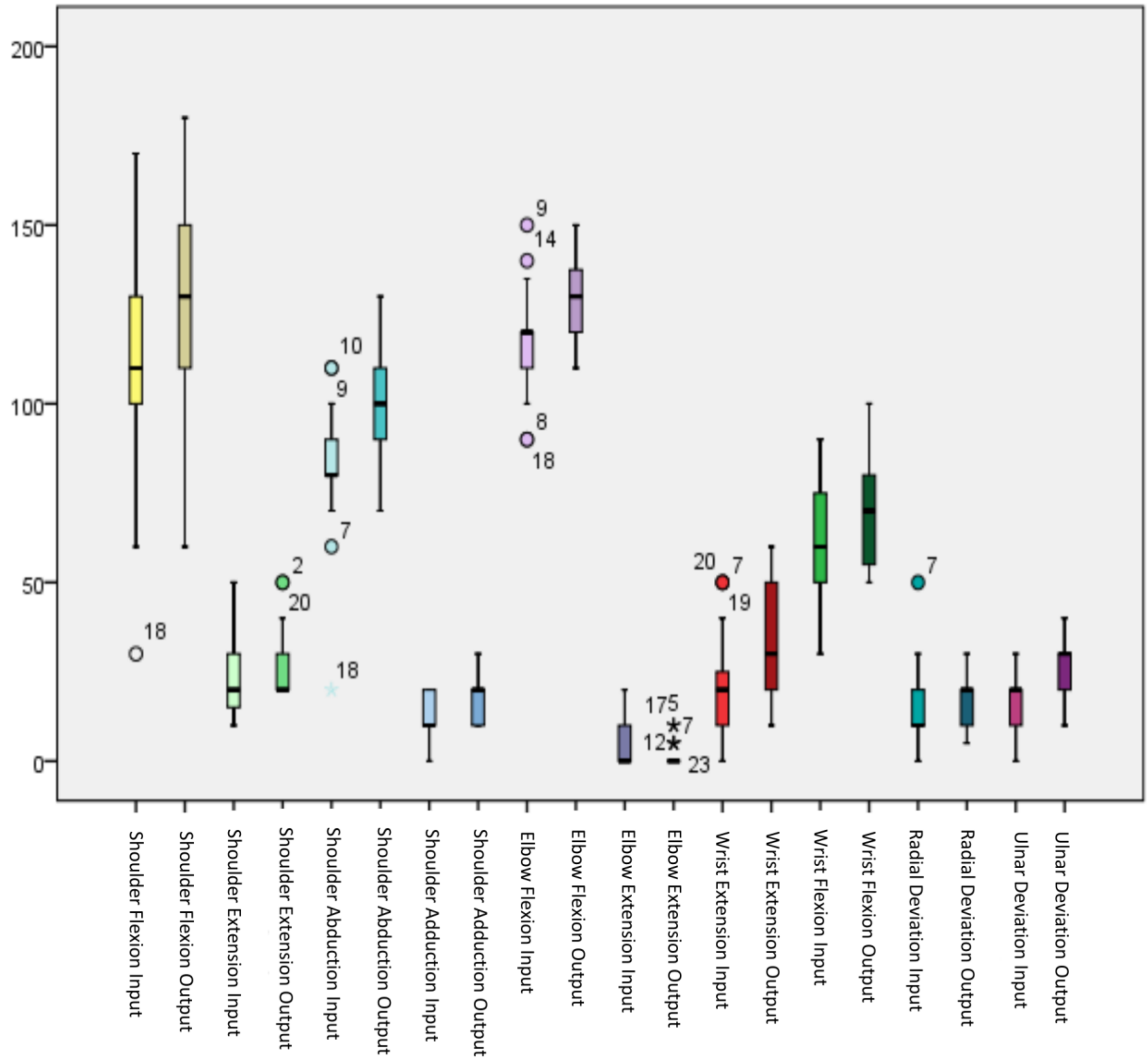
After rehabilitation by equipment Armeo®, the children achieved greater range of motions in the upper extremity. After the testing of obtained input and output data, we used tests of normality (Kolmogorov - Smirnov and Shapiro - Wilk). The tests have confirmed homogeneous and inhomogeneous distribution of the data in the study, we used parametric statistical test - Student's paired dependent t-test and nonparametric statistical test - Wilcoxon Signed Ranks Test. After the treatment has occurred in children to statistically significant improvements in range of motions of the upper extremity which resulted in a higher average output score in shoulder flexion (M = 130, SD ± 31) than the input score (M = 110, SD ± 30), t (23) = -9,045, p = 0,000, a higher average output score in shoulder abduction (M = 100, SD ± 14) than the input score (M = 80, SD ± 18), Z (23) = -4,141, p = 0,000, a higher average output score in elbow flexion (M = 130, SD ± 12) than the input score (M = 120, SD ± 15), Z (23) = - 3,669, p = 0,000, a higher average output score in elbow extension (M = 0, SD ± 3) than the input score (M = 0, SD ± 7), Z (23) = - 3,035, p = 0,002, a higher average output score in wrist extension (M = 30, SD ± 18) than the input score (M = 20, SD ± 15), Z (23) = - 3,858, p = 0,000, a higher average output score in radial deviation (M = 20, SD ± 7) than the input score (M = 10, SD ± 11), Z (23) = - 2,560, p = 0,010 (Table 1, Graph 1).

Table 1: Descriptive statistic of the measurement range of motion of the upper extremity

Descriptive

	Count	Mean	Maximum	Minimum	Median	Standard Error of Mean	Standard Deviation	Student t-test/Wilcoxon Signed Ranks Test	Sig. (2-tailed)
Shoulder Flex. Input	23	111	170	30	110	6	30	t = -9,045	,000
Shoulder Flex. Output	23	131	180	60	130	7	31		
Shoulder Ext. Input	23	22	50	10	20	2	10	Z = -3,357	,001
Shoulder Ext. Output	23	28	50	20	20	2	10		
Shoulder Abd. Input	23	83	110	20	80	4	18	Z = -4,141	,000
Shoulder Abd. Output	23	97	130	70	100	3	14		
Shoulder Add. Input	23	14	20	0	10	1	6	Z = - 2,646	,008
Shoulder Add. Output	23	17	30	10	20	1	6		
Elbow Flex. Input	23	117	150	90	120	3	15	Z = - 3,669	,000
Elbow Flex. Output	23	129	150	110	130	2	12		
Elbow Ext. Input	23	5	20	0	0	1	7	Z = - 3,035	,002
Elbow Ext. Output	23	2	10	0	0	1	3		
Wrist Ext. Input	23	21	50	0	20	3	15	Z = - 3,858	,000
Wrist Ext. Output	23	33	60	10	30	4	18		
Wrist Flex. Input	23	60	90	30	60	4	19	t = -6,521	,000
Wrist Flex. Output	23	70	100	50	70	3	17		
Radial Deviat. Input	23	14	50	0	10	2	11	Z = - 2,560	,010
Radial Deviat. Output	23	18	30	5	20	2	7		
Ulnar Deviat. Input	23	17	30	0	20	2	8	Z = 4,184	,000
Ulnar Deviat. Output	23	26	40	10	30	1	7		

Flex. - flexion, Ext. - extension, Abd. - abduction, Add. - adduction, Deviat. - deviation



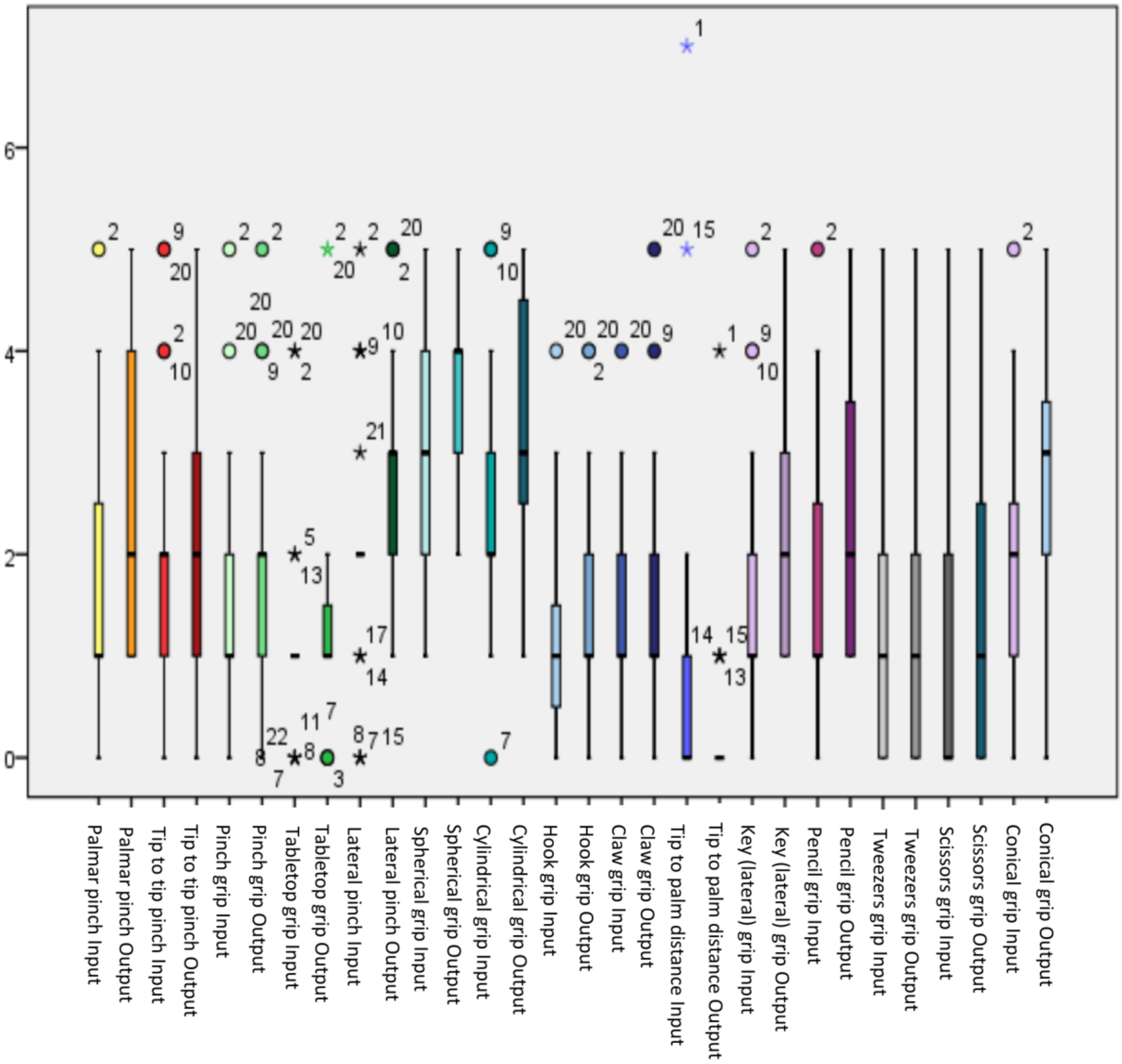
Graph 1: Graphical representation of the measurement range of motion of the upper extremity

Significantly better results demonstrated the improvement in hand grip which resulted in a higher average output score in lateral pinch (M = 3 SD ± 1) compared with the input score (M = 2 ± SD 1), Z (23) = - 3,900, p = 0,000, a higher average output score in spherical grip (M = 4 SD ± 1) compared with the input score (M = 3 ± SD 1), Z (23) = -3,827, p = 0,000, a higher average output score in cylindrical grip (M = 3 SD ± 1) compared with the input score (M = 2 ± SD 1), Z (23) = -4,001, p = 0,000, a higher average output score in key (lateral) grip (M = 2 SD ± 1) compared with the input score (M = 1 ± SD 1), Z (23) = -3,500, p = 0,000, a higher average output score in conical grip (M = 3 SD ± 1) compared with the input score (M = 2 ± SD 1), Z (23) = -3,500, p = 0,000 (Table 2, Graph 2).

Table 2: Descriptive statistics of the testing grips of paretic´s hand

Descriptive

	Count	Mean	Maximum	Minimum	Median	Standard Error of Mean	Standard Deviation	Wilcoxon Signed Ranks Test	Asymp. Sig. (2-tailed)
Palmar pinch Input	23	1,91	5	0	1	0	1	-3,051	,002
Palmar pinch Output	23	2,39	5	1	2	0	1		
Tip to tip pinch Input	23	1,91	5	0	2	0	1	-3,162	,002
Tip to tip pinch Output	23	2,35	5	0	2	0	2		
Pinch grip Input	23	1,52	5	0	1	0	1	-3,464	,001
Pinch grip Output	23	2,04	5	0	2	0	1		
Tabletop grip Input	23	1,13	4	0	1	0	1	-2,449	,014
Tabletop grip Output	23	1,39	5	0	1	0	1		
Lateral pinch Input	23	2,09	5	0	2	0	1	-3,900	,000
Lateral pinch Output	23	2,83	5	1	3	0	1		
Spherical grip Input	23	2,87	5	1	3	0	1	-3,827	,000
Spherical grip Output	23	3,78	5	2	4	0	1		
Cylindrical grip Input	23	2,48	5	0	2	0	1	-4,001	,000
Cylindrical grip Output	23	3,39	5	1	3	0	1		
Hook grip Input	23	1,22	4	0	1	0	1	-2,449	,014
Hook grip Output	23	1,48	4	0	1	0	1		
Claw grip Input	23	1,26	4	0	1	0	1	-3,162	,002
Claw grip Output	23	1,70	5	0	1	0	1		
Tip to palm distance Input	23	0,78	7	0	0	0	2	-2,032	,042
Tip to palm distance Output	23	0,30	4	0	0	0	1		
Key (lateral) grip Input	23	1,65	5	0	1	0	1	-3,500	,000
Key (lateral) grip Output	23	2,26	5	1	2	0	1		
Pencil grip Input	23	1,83	5	0	1	0	1	-2,972	,003
Pencil grip Output	23	2,35	5	1	2	0	1		
Tweezers grip Input	23	1,13	5	0	1	0	1	-2,646	,008
Tweezers grip Output	23	1,43	5	0	1	0	1		
Scissors grip Input	23	0,96	5	0	0	0	1	-3,162	,002
Scissors grip Output	23	1,39	5	0	1	0	1		
Conical grip Input	23	1,96	5	0	2	0	1	-3,500	,000
Conical grip Output	23	2,57	5	0	3	0	1		



Graph 2: Graphical representations of the testing grips of paretic´s hand

Discussion

Krebs[11] published a study, where he tested in children with cerebral palsy (CP). He tested whether or not motor habilitation resembles motor learning. Twelve children with hemiplegic CP, aged 5 to 12 years with moderate to severe motor impairments underwent a 16-session robot-mediated planar therapy program to improve their upper extremity reach, with a focus on shoulder and elbow movements. Participants were trained to execute point-to-point movements (with robot assistance) with the affected arm and were evaluated (without robot assistance) in trained (point-to-point) and untrained (circle-drawing) conditions. Outcomes were measured at baseline, midpoint, immediately after the program, and 1 month post completion. Outcomes measured were the Fugl-Meyer (FM), Quality of Upper Extremity Skills Test (QUEST), and Modified Ashworth Scale (MAS) scores; parent questionnaire; and robot-based kinematic metrics. After robotic intervention, the authors found significant gains in the FM, QUEST, and parent questionnaire. Robot-based evaluations demonstrated significant improvement in trained movements and that improvement was sustained at follow-up. Furthermore, children improved their performance in untrained movements indicating generalization. Therapy in our study was focused to determine the effect of non-robotic therapy for children with hemiparesis syndrome. We focused on improving the range of motion in the upper extremity and improving grips of paretic hand.

Armeo® Spring is an effected tool for rehabilitating the affected arm in patients with hemiparesis secondary to ictus, even in the chronic stage[12]. We agree with the authors of the study, and we deliver treatment success by using Armeo® in children with cerebral palsy, namely primary hemiparesis.

Studies have confirmed significant improvement in mobility of the upper extremity in patients with hemiparesis. It has increased the muscle strength, increased the range of joint mobility, improved the neuromuscular coordination, improved the upper extremity function, and increased the patient's motivation and lastly the improvement of self-sufficiency. The results of the available studies have supported the current theory of motor learning by repeating the motions, which it describes the correlation between the repetition of activities and improving motor function, therefore being the key to stimulate motor plasticity[13]. We agree with the authors opinion in regards to the pursuance of acquired results, we described similar findings in a child with cerebral palsy after treatment in non-robotic device Armeo®.

Robotic and non-robotic training devices are increasingly being used in the rehabilitation of upper extremity function in subjects with neurological disorders. As well as being used for training such devices can also provide ongoing assessments during the training sessions. Therefore, it is mandatory to understand the reliability and validity of such measurements when used in a clinical setting[14]. We consent, therefore started using non-robotic Armeo® equipment in our rehabilitation centre.

We agree with the author's opinion in regards that in pursuance of acquired results we described similar findings in a patient with cerebral palsy after treatment in non-robotic equipment Armeo®. Therapeutic allowances, such as robotic therapy can be viewed as a promising development. Robotic therapy allows for patients to practice independently without a therapist, and thus help to improve their own functional level. In particular, there is strong evidence for robotically assisted therapy, because it will increase compliance with therapy by means of introduction of incentives to the patient, such as games[15]. We have to agree here with the authors of international clinical studies, because it has showed greater interest in the therapy from the patient´s side and greater motivation especially in children and adolescence age, where it is well known that it is difficult to motivate and to improve attention in therapy.

Robot assisted upper extremity therapy has been shown to be effective in adult stroke patients and in children with cerebral palsy (CP) and other acquired brain injuries (ABI). The patient's active involvement is a factor with its effectiveness. However this demands focused attention during training sessions, which can be a challenge for children[16]. We agree with the authors, however with our children, we would like to highlight the increased attention needed, because then the games would interest them and they would be completely focused on the therapy.

Conclusion

Significantly positive results were achieved due to Armeo® system. Therapy has improved the range of motion in the hemiparetic upper extremity and similarly significant results have been shown in improvements in grip ability of paretic hand. The co-operation with children during the non-robotic therapy was very good. They were coming to the therapy regularly and really looking forward to it. We can say based on the analysis results, that non-robotic therapy of Armeo® positively effects the rehabilitation of the children with cerebral palsy (hemiparesis). We would like to emphasize not only the positive effect of therapy, but also the patient's successfulness of motivation in the adolescent age. Although the therapy in system of Armeo® is more costly than conventional methods, successfulness of the treatment has a very high rate, as indicated by other authors in their articles. As we know, we can never completely get a patient with hemiparesis back to full health, but we can help them to improve the function and self-sufficiency of paretic upper extremity with interesting non-robotic therapy with Armeo® device.

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