Chapter 6

Impact of Non-Robotic Assisted Therapy for Improvement of Mobility of Paretic Upper Extremity Caused by Cerebral Palsy Compared to Classical Kinesiotherapy

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Additional information is available at the end of the chapter

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Abstract

Background: The aim of the clinical study was to investigate and compare the impact of non-robotic assisted therapy to classical kinesiotherapy to improve the function abilities of upper extremity.

Patients and methods: Sixty patients were divided randomly into two study groups. In the main group, patients completed a non-robotic assisted therapy and in the comparative group, they completed a classical kinesiotherapy. The age range of patients was from 6 to 17 years of age with impaired upper extremity. They all participated in 20 therapies.

Results: Statistically significant results were obtained in patients who completed the Armeo® therapy in all ranges of motion, the best improvement ($p = 0.000$) of shoulder and elbow flexion, and wrist extension, in all grips of the hand, the best improvement ($p = 0.000$) in lateral pinch, spherical and cylindrical grip and in Frenchay Arm Test in all tasks, the best improvement ($p = 0.000$) in tasks 1 and 5. The comparative group of the patients achieved statistically significant results only in elbow flexion ($p = 0.005$), radial deviation ($p = 0.046$), in ulnar deviation ($p = 0.011$). In other movements, grips and tasks were the results that are not statistically significant.

Conclusion: For the improvement of function ability of the paretic upper extremity, the patients with cerebral palsy are statistically more effective from the non-robotic assisted therapy than those who completed the classical kinesiotherapy.

Keywords: cerebral palsy, upper extremity, non-robotic assisted therapy, classical kinesiotherapy

1. Introduction

This clinical study has tested improvement of the movements of upper extremity in children and adolescents with cerebral palsy (CP). Arm rehabilitation is applied in neurorehabilitation for patients with paralyzed upper extremities due to lesions of the central or peripheral nervous system, for example, after stroke or spinal cord injury [1]. Lengthy physical inactivity in patients with chronic neurological disease can lead to prolonged recovery [2]. The goals of the therapy are to recover motor function, to improve movement coordination, to learn new motion strategies ("trick movements"), and/or to prevent secondary complications such as muscle atrophy, osteoporosis, and spasticity. The advantages of robotic training are that the therapist can get assisted, for example, relieved from the weight of the patient's arm, the training can get longer and more intensive (up to 20 times more movement repetitions per training session), and the movements can be measured and used for therapy assessment. Furthermore, special virtual reality technologies can make the training much more entertaining and motivating as well as task-oriented and functional and, thus, more relevant for daily living activities [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 include 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 [3]. One of the clinical features of cerebral palsy that perhaps has been least appreciated is impaired selective motor control (SMC). The National Institutes of Health Task Force defined SMC as the 'ability to isolate the activation of muscles in a selected pattern in response to demands of a voluntary movement or posture'. This can be extended to include movement of intended body segments in isolation. The intricate process of developing motor pathways establishing connections at the spinal-segmental level is susceptible to prenatal and perinatal brain damage that affect SMC. For example, it has long been established that the corticospinal tract directly innervates hand motor neurons, which provides the capacity for selective upper extremity movement control, and that damage to these tracts impairs this control [4]. 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

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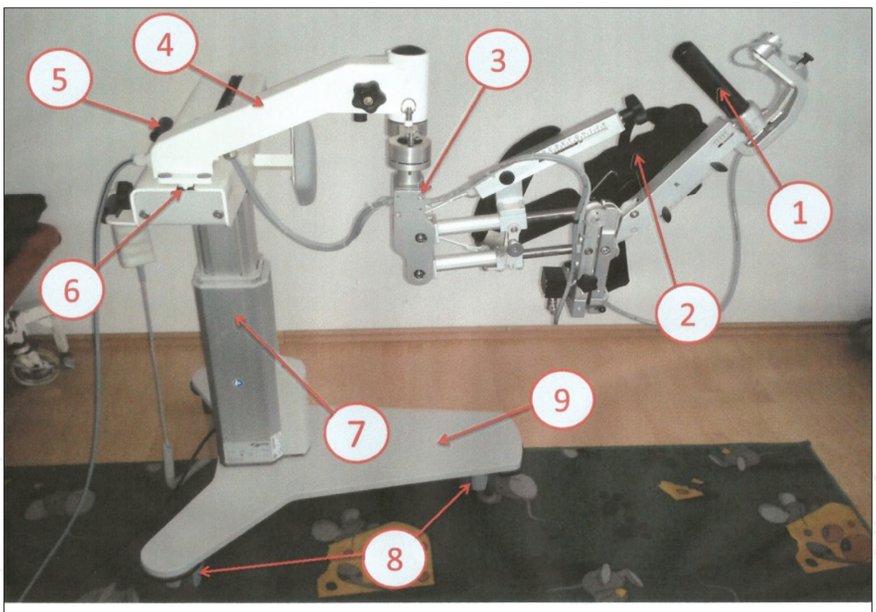
performance, limitations in mobility, high calorie demands for growth, and decreased aerobic capacity [5]. Hemiparesis is usually a lifelong health problem, but is not unsolvable. By the effort to stifle debilitating disorder in hemiparesis and to therefore prevent its progression, it needs to be followed 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].

1.1. Non-robotic therapy by Armeo® equipment

The therapy was implemented by means of the 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. Taking into account the contraindications and every patient's individual profile, the Armeo® is used in the case of: strokes, multiple sclerosis (MS), cerebral palsy (CP), follow-up care after brain-tumor operations, spinal cord injuries (SCI), traumatic brain injury (TBI), endoprostheses, follow-up care for elbow and shoulder endoprostheses, muscular atrophy, muscle weakness due to lack of mobility, hemiplegic patients. Just as for any other therapy, the physician in charge is always responsible for the indication. Functional training with the Armeo® is not possible or indicated in every case. In general, the Armeo® must not be used in the following cases to avoid causing harm to the patient. The following contraindications must therefore be observed in particular: orthosis cannot be fitted to the relevant arm, bone instability (non-consolidated fractures, severe osteoporosis), pronounced, fixed contractures affecting the relevant extremity, open skin lesions in the area of the relevant upper extremity, paraesthesia, shoulder joint subluxation or pain in the shoulder joint, severe spasticity, severe spontaneous movements, for example, ataxia, dyskinesia, myoclonic jerks, non-stable vital functions: pulmonary or cardio-circulatory contraindications (instability or instrumental support for these functions), need for long-term infusion therapy, severe postural instability, contraindicated sitting position, confused or non-cooperative patients, severe cognitive deficits, patients requiring isolation due to infections, severe visual problems (patient is not able to see displayed elements on the computer screen).

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 that is possible without derating weight of the upper extremity. It also allows the 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 [7] (**Figures 1** and **2**).

Figure 1. Therapy by using Armeo® equipment in 3D workspace.



1.Caster
2.Base plate
3.Lifting column
4.Linear guide
5.Transport handle
6.Arm with integrated electronics
7.Upper arm module with weight compensation mechanism and cuff
8.Forearm module with weight compensation mechanism and cuff
9.Pressure sensitive handle with degree of freedom for pronation / supination

Figure 2. General overview of Armeo® equipment according to Hocoma (2008).

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After the setting of therapy, the patient performs the specified sequence of exercise as an individual training. All exercises are performed in environment of virtual reality, which clearly displays functional tasks and performances of the patient [7]. Therapists can choose exercises, which they want to add to the users' therapy plan (e.g., Window Mopping, Reveal Panorama, Popping Air Bubbles) (**Figures 3** and **4**) [7]. Upon adding new exercises to the therapy plan, the plan definition screen appears. In this screen, all the exercise parameters such as difficulty level, time limits, number of repetitions and so on can be adjusted to the patients' needs. The Augmented Performance Feedback provided by the shared software platform, encourages and motivates patients to achieve a higher number of repetitions, and this leads to better, faster results and improved long-term outcomes. The software also provides automatic, ongoing assessment of motor functions and patients that can readily track their progress, helping them to grasp the initiative and reach toward recovery [7].

Figure 3. Grating carrot.

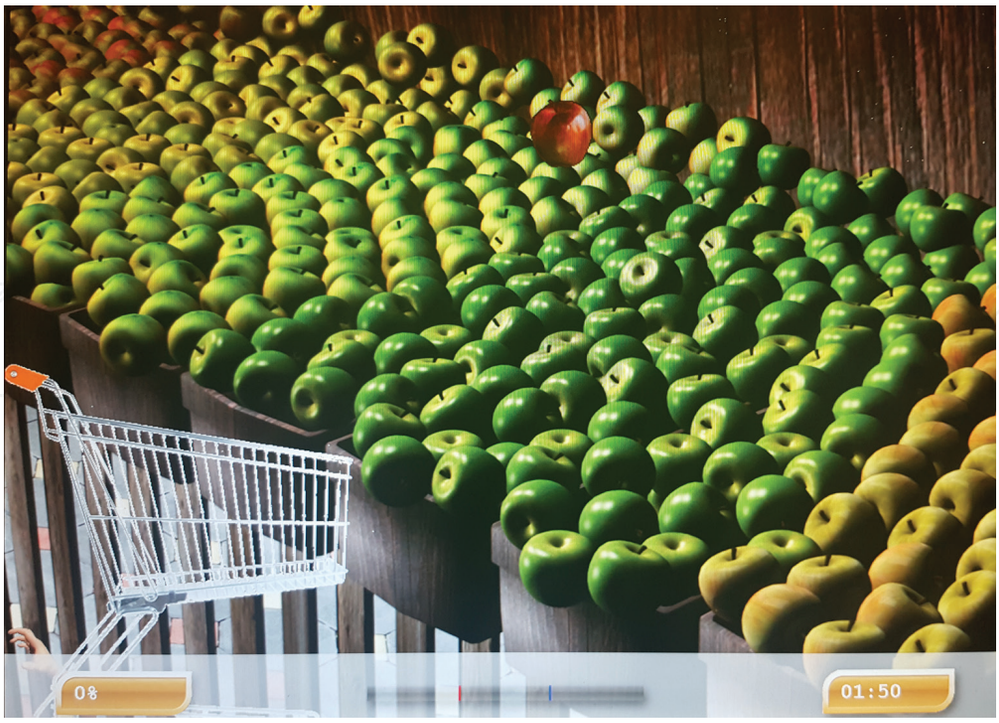

Figure 4. Shopping in 3D workplace.

The purpose of this clinical 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 and adolescents with cerebral palsy. In this study, we sought to identify and verify the comparison of the impact of non-robotic assisted therapy to classical kinesiotherapy on the functionality effect of self-sufficiency and improvements of paretic upper extremity in the patients with CP. Even though we know that the complete elimination of paresis is impossible, we believe that paresis of the upper extremity can effect to a large extent, so that children and adolescents can improve their independence and quality of life.

2. Patients and methods

The object of investigation consisted of two groups. In the main group, patients completed a non-robotic assisted therapy and in the comparative group they completed a classical kinesiotherapy (e.g., passive movements, active-assisted exercises, Bobath concept, Kabat method). The age range of patients was from 6 to 17 years of age with impaired upper extremity. In the main group: 30 children (mean age 12.73) and in the comparative group: 30 children (mean age 11.33).They all have taken 20 therapies, whereas in the main group by Armeo® equipment and in the comparison group by classical kinesiotherapy. One therapy lasted 45 min of active exercise and frequency was minimal to twice a week. The patients were tested before and after the completion of therapy using goniometric investigation [7], by testing grips of paretic's hand (cylindrical, spherical, lateral, hook…) [8] and by using Frenchay Arm Test [9] for investigation of function ability of paretic upper extremity.

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2.1. The statistical methods used in the study

For processing the collected data, a numerical evaluation and statistical methods were chosen. It was used as a descriptive analysis, Student's paired dependent t-test, Wilcoxon Signed Ranks Test and Effect size. Student's paired dependent t-test was used to evaluate the range of motion of the upper extremity for shoulder flexion and extension, wrist flexion and for evaluating the hand grip for palmar pinch, pinch grip and hook grip 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 higher than 0.05, then our observation of an intervention is not random. For other range of motions of the upper extremity and for other evaluation, the hand grip was used the Wilcoxon Signed Ranks Test – nonparametric statistical test, because in comparing to the test of the range of motions didn't work the test of normality for variances. This test does not compare the obtained values but the order of assigned values from the smallest to the largest. The study also shows the effect size. Effect size is used to obtain the size of standard rates of our observations. Effect size with significance, gives us information about the size and significance of the effect. Data were processed by using the software Microsoft Office Word 2007, Microsoft Office Excel, 2007. For mathematical-statistical evaluation, descriptive statistical methods SPSS 16.0 were used.

The study was conducted in accordance with ethical principles, based on the Declaration of Helsinki (1964) [10].

3. Results

In the main group after rehabilitation by equipment Armeo®, the patients achieved greater range of motions in the upper extremity than the patients in comparison group. 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 had occurred in the patients of the main group, there was statistically significant improvements in range of motions of the upper extremity, which resulted in a higher average output score in shoulder flexion ($M = 131.83$, $SD \pm 29.55$) than the input score ($M = 111.33$, $SD \pm 32.59$), $t(29) = -7.894$, $p = 0.000$, $r = 0.826$, a higher average output score in shoulder abduction ($Md = 100.00$, $SD \pm 15.60$) than the input score ($Md = 82.50$, $SD \pm 20.91$), $T = 0.00$, $Z(30) = -4.642$, $p = 0.000$, $r = -0.599$, a higher average output score in elbow flexion ($Md = 130.00$, $SD \pm 11.84$) than the input score ($Md = 120.00$, $SD \pm 13.61$), $T = 0.00$, $Z(30) = -4.342$, $p = 0.000$, $r = -0.561$, a lower average output score in elbow extension ($Md = 0.00$, $SD \pm 4.69$) than the input score ($Md = 5.00$, $SD \pm 7.03$), $T = 0.00$, $Z(30) = -3.397$, $p = 0.001$, $r = -0.439$, because in elbow extension it has achieved the reduction until to elimination of flexion contractures, a higher average output score in wrist extension ($Md = 30.00$, $SD \pm 18.02$) than the input score ($Md = 20.00$, $SD \pm 15.83$), $T = 0.00$, $Z(30) = -4.371$, $p = 0.000$, $r = -0.564$, a higher average output score in radial deviation ($Md = 20.00$, $SD \pm 7.93$) than the input score ($Md = 20.00$, $SD \pm 10.97$), $T = 0.00$, $Z(30) = -3.154$, $p = 0.002$, $r = -0.407$. Statistically significant improvements also occurred in the other range of motions of the upper extremity (**Table 1**).

	Count	Mean	Maximum	Minimum	Median	Standard error of mean	Standard deviation	Student t-test/ Wilcoxon signed ranks test	Sig. (two-tailed)	Effect size
Shoulder flex. input	30	111.33	170	30	110	5.950	32.588	t = −7.894	0.000	r = 0.826
Shoulder flex. output	30	131.83	180	60	130	5.395	29.551			
Shoulder ext. input	30	23.83	50	10	20	2.001	10.961	Z = −3.823	0.000	r = −0.493
Shoulder ext. output	30	29.83	50	20	30	1.864	10.212			
Shoulder abd. input	30	83.83	130	20	82.50	3.818	20.914	Z = −4.642	0.000	r = −0.599
Shoulder abd. output	30	98.50	130	70	100	2.848	15.600			
Shoulder add. input	30	15.17	25	0	20	1.085	5.943	Z = −2.972	0.003	r = −0.384
Shoulder add. output	30	18.17	30	10	20	1.002	5.490			
Elbow flex. input	30	118.17	150	90	120	2.485	13.613	Z = −4.342	0.000	r = −0.561
Elbow flex. output	30	130.50	150	110	130	2.162	11.843			
Elbow ext. input	30	6.17	20	0	5	1.284	7.032	Z = −3.397	0.001	r = −0.439
Elbow ext. output	30	2.50	20	0	0	0.856	4.689			

	Count	Mean	Maximum	Minimum	Median	Standard error of mean	Standard deviation	Student t-test/ Wilcoxon signed ranks test	Sig. (two-tailed)	Effect size
Wrist ext. input	30	20.50	50	0	20	2.890	15.830	Z = −4.371	0.000	r = −0.564
Wrist ext. output	30	31.67	60	5	30	3.290	18.020			
Wrist flex. input	30	67.50	110	30	70	4.088	22.390	t = −6.456	0.000	r = 0.768
Wrist flex. output	30	76.67	130	50	80	3.670	20.100			
Radial deviat. input	30	15.67	50	0	20	2.002	10.965	Z = −3.154	0.002	r = −0.407
Radial deviat. output	30	20.17	35	5	20	1.448	7.931			
Ulnar deviat. input	30	17.33	30	0	20	1.413	7.739	Z = −4.288	0.000	r = −0.554
Ulnar deviat. output	30	24.67	40	10	22.50	1.290	7.063			

Flex., flexion; ext., extension; abd., abduction; add., adduction; deviat., deviation.

Table 1. Descriptive statistic of the measurement range of motion of the upper extremity in the main group of patients, who completed non-robotic therapy.

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In the patients of the comparison group, there was statistically significant improvements in range of motions of the upper extremity only in the three motions, which resulted in a higher average output score in elbow flexion (Md = 140.00, SD ± 13.88) than the input score (Md = 140.00, SD ± 13.88), T = 0.00, Z(30) = −2.828, p = 0.005, r = −0.365, a higher average output score in radial deviation (Md= 10.00, SD ± 9.21) than the input score (Md = 10.00, SD ± 9.26), T = 0.00, Z(30) = −2.000, p = 0.046, r = −0.258, a higher average output score in ulnar deviation (Md = 20.00, SD ± 14.37) than the input score (Md = 20.00, SD ± 13.81), T = 0.00, Z(30) = −2.530, p = 0.011, r = −0.327. In the other range of motions have not occurred statistically significant improvements of the upper extremity (**Table 2**).

	Count	**Mean**	**Maximum**	**Minimum**	**Median**	**Standard error of mean**	**Standard deviation**	**Student t-test/ Wilcoxon signed ranks test**	**Sig. (two-tailed)**	**Effect size**
Shoulder flex. input	30	99.50	150	60	90	4.357	23.866	Z = −1.633	0.102	*
Shoulder flex. output	30	100.23	160	60	90	4.447	24.359			
Shoulder ext. input	30	27.67	60	0	30	2.783	15.241	t = −1.439	0.161	*
Shoulder ext. output	30	28.00	60	0	30	2.729	14.948			
Shoulder abd. input	30	85.50	130	20	90	3.493	19.134	Z = −1.000	0.317	*
Shoulder abd. output	30	85.67	130	20	90	3.505	19.197			
Shoulder add. input	30	26.83	45	0	22.50	2.790	15.284	Z = −1.414	0.157	*
Shoulder add. output	30	27.17	45	5	25	2.741	15.011			
Elbow flex. input	30	132.5	145	100	140	2.534	13.881	Z = −2.828	0.005	r = −0.365
Elbow flex. output	30	133.83	150	100	140	2.533	13.877			
Elbow ext. input	30	7.83	40	0	5	1.773	9.710	Z = −1.414	0.157	*
Elbow ext. output	30	7.50	40	0	5	1.741	9.537			
Wrist ext. input	30	32.50	70	0	30	4.233	23.184	Z = 0.000	1.000	*
Wrist ext. output	30	32.50	70	0	30	4.233	23.184			
Wrist flex. input	30	42.17	60	10	47.50	3.039	16.645	t = −1.633	0.102	*
Wrist flex. output	30	42.83	60	10	47.50	2.982	16.331			

	Count	Mean	Maximum	Minimum	Median	Standard error of mean	Standard deviation	Student t-test/ Wilcoxon signed ranks test	Sig. (two-tailed)	Effect size
Radial deviat. input	30	12.83	30	0	10	1.690	9.255	Z = −2.000	0.046	r = −0.258
Radial deviat. output	30	13.50	30	0	10	1.681	9.206			
Ulnar deviat. input	30	21.17	50	0	20	2.522	13.814	Z = −2.530	0.011	r = −0.327
Ulnar deviat. output	30	22.50	55	0	20	2.623	14.369			

Flex., flexion; ext., extension; abd., abduction; add., adduction; deviat., deviation.

*Not-statistically significant $p \geq 0.05$.

Table 2. Descriptive statistic of the measurement range of motion of the upper extremity in the comparison group of patients, who completed classical kinesiotherapy.

Significantly better results demonstrated the improvement in hand grip in the main group of patients, which resulted in a higher average output score in lateral pinch (Md = 3.00, SD ± 1.19) compared with the input score (Md = 2.00, SD ± 1.44), T = 0.00, Z(30) = −4.264, p = 0.000, r = −0.550, a higher average output score in spherical grip (Md = 4.00, SD ± 0.92) compared with the input score (Md = 3.00, SD ± 1.30), T = 0.00, Z(30) = −4.400, p = 0.000, r = −0.568, a higher average output score in cylindrical grip (Md = 3.50, SD ± 1.22) compared with the input score (Md = 2.00, SD ± 1.32), T = 0.00, Z(30) = −4.534, p = 0.000, r = −0.589, a higher average output score in key (lateral) grip (Md = 2.00, SD ± 1.22) compared with the input score (Md = 1.00, SD ± 1.31), T = 0.00, Z(30) = −4.001, p = 0.000, r = −0.516, a higher average output score in scissors grip (Md = 1.00, SD ± 1.45) compared with the input score (Md = 0.00, SD ± 1.39), T = 0.00, Z(30) = −4.000, p = 0.000, r = −0.516, a higher average output score in conical grip (Md = 3.00, SD ± 1.22) compared with the input score (Md = 2.00, SD ± 1.37), T = 0.00, Z(30) = −4.025, p = 0.000, r = −0.520 (**Table 3**).

	Count	Mean	Maximum	Minimum	Median	Standard error of mean	Standard deviation	Wilcoxon signed ranks test	Asymp. sig. (two-tailed)	Effect size
Palmar pinch input	30	1.90	5	0	1.50	0.232	1.269	Z = −3.771	0.000	r = −0.487
Palmar pinch output	30	2.43	5	1	2.00	0.238	1.305			

	Count	Mean	Maximum	Minimum	Median	Standard error of mean	Standard deviation	Wilcoxon signed ranks test	Asymp. sig. (two-tailed)	Effect size
Tip to tip pinch input	30	1.97	5	0	2.00	0.277	1.520	Z = −3.742	0.000	r = −0.483
Tip to tip pinch output	30	2.43	5	0	2.00	0.290	1.591			
Pinch grip input	30	1.60	5	0	1.00	0.233	1.276	Z = −3.742	0.000	r = −0.483
Pinch grip output	30	2.07	5	0	2.00	0.230	1.258			
Tabletop grip input	30	1.17	4	0	1.00	0.215	1.177	Z = −3.162	0.002	r = −0.408
Tabletop grip output	30	1.50	5	0	1.00	0.248	1.358			
Lateral pinch input	30	2.30	5	0	2.00	0.263	1.442	Z = −4.264	0.000	r = −0.550
Lateral pinch output	30	2.97	5	1	3.00	0.217	1.189			
Spherical grip input	30	3.03	5	1	3.00	0.237	1.299	Z = −4.400	0.000	r = −0.568
Spherical grip output	30	3.90	5	2	4.00	0.168	0.923			
Cylindrical grip input	30	2.67	5	0	2.00	0.241	1.322	Z = −4.534	0.000	r = −0.589
Cylindrical grip output	30	3.53	5	1	3.50	0.224	1.224			
Hook grip input	30	1.30	4	0	1.00	0.221	1.208	Z = −2.972	0.003	r = −0.384
Hook grip output	30	1.70	4	0	1.00	0.254	1.393			
Claw grip input	30	1.43	4	0	1.00	0.218	1.194	Z = −3.500	0.000	r = −0.452
Claw grip output	30	1.90	5	0	1.50	0.26	1.423			
Tip to palm distance input	30	0.60	7	0	0.00	0.286	1.567	Z = −2.032	0.042	r = −0.262
Tip to palm distance output	30	0.23	4	0	0.00	0.141	0.774			
Key (lateral) grip input	30	1.50	5	0	1.00	0.239	1.306	Z = −4.001	0.000	r = −0.516
Key (lateral) grip output	30	2.20	5	1	2.00	0.222	1.215			

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	Count	Mean	Maximum	Minimum	Median	Standard error of mean	Standard deviation	Wilcoxon signed ranks test	Asymp. sig. (two-tailed)	Effect size
Pencil grip input	30	1.87	5	0	1.00	0.261	1.432	Z = −3.494	0.000	r = −0.451
Pencil grip output	30	2.43	5	1	2.00	0.228	1.251			
Tweezers grip input	30	1.30	5	0	1.00	0.250	1.368	Z = −3.317	0.001	r = −0.428
Tweezers grip output	30	1.67	5	0	1.50	0.251	1.373			
Scissors grip input	30	1.07	5	0	0.00	0.253	1.388	Z = −4.000	0.000	r = −0.516
Scissors grip output	30	1.60	5	0	1.00	0.265	1.453			
Conical grip input	30	2.00	5	0	2.00	0.249	1.365	Z = −4.025	0.000	r = −0.520
Conical grip output	30	2.60	5	0	3.00	0.223	1.221			

Table 3. Descriptive statistics of the testing grips of paretic's hand in the main group of patients, who completed non-robotic therapy.

In testing grips of paretic's hands, there were statistically significant results of the main group of patients, unlike of the comparative group of patients, where they have not achieved statistically significant results in testing of paretic's hands (**Table 4**).

	Count	Mean	Maximum	Minimum	Median	Standard error of mean	Standard deviation	Student t-test/ Wilcoxon signed ranks test	Asymp. sig. (two-tailed)	Effect size
Palmar pinch input	30	2.87	5	0	3.00	0.313	1.717	t = −1.795	0.083	*
Palmar pinch output	30	2.97	5	0	3.00	0.294	1.608			
Tip to tip pinch input	30	2.80	5	0	3.00	0.337	1.846	Z = −1.732	0.083	*
Tip to tip pinch output	30	2.90	5	0	3.00	0.312	1.709			
Pinch grip input	30	2.37	5	0	2.00	0.327	1.790	t = −1.439	0.161	*
Pinch grip output	30	2.43	5	0	2.50	0.321	1.755			

	Count	Mean	Maximum	Minimum	Median	Standard error of mean	Standard deviation	Student t-test/ Wilcoxon signed ranks test	Asymp. sig. (two-tailed)	Effect size
Tabletop grip input	30	1.93	5	0	2.00	0.321	1.760	Z = −1.414	0.157	*
Tabletop grip output	30	2.00	5	0	2.00	0.314	1.722			
Lateral pinch input	30	2.57	5	0	3.00	0.313	1.716	Z = −1.000	0.317	*
Lateral pinch output	30	2.60	5	0	3.00	0.306	1.673			
Spherical grip input	30	3.40	5	0	4.00	0.286	1.567	Z = −1.414	0.157	*
Spherical grip output	30	3.47	5	0	4.00	0.278	1.525			
Cylindrical grip input	30	3.63	5	0	4.00	0.297	1.629	Z = −1.732	0.083	*
Cylindrical grip output	30	3.73	5	0	4.00	0.291	1.596			
Hook grip input	30	2.43	5	0	2.50	0.298	1.633	t = −1.439	0.161	*
Hook grip output	30	2.50	5	0	2.50	0.295	1.614			
Claw grip input	30	2.13	5	0	2.00	0.310	1.697	Z = −0.000	1.000	*
Claw grip output	30	2.13	5	0	2.00	0.310	1.697			
Tip to palm distance input	30	0.53	5	0	0.00	0.243	1.332	Z = −1.414	0.157	*
Tip to palm distance output	30	0.47	5	0	0.00	0.218	1.196			
Key (lateral) grip input	30	2.97	5	0	3.00	0.320	1.752	Z = −1.414	0.157	*
Key (lateral) grip output	30	3.03	5	0	3.00	0.301	1.650			
Pencil grip input	30	2.50	5	0	3.00	0.306	1.676	Z = −1.732	0.083	*
Pencil grip output	30	2.60	5	0	3.00	0.309	1.694			

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	Count	Mean	Maximum	Minimum	Median	Standard error of mean	Standard deviation	Student t-test/ Wilcoxon signed ranks test	Asymp. sig. (two-tailed)	Effect size
Tweezers grip input	30	2.47	5	0	2.00	0.348	1.907	Z = −1.000	0.317	*
Tweezers grip Output	30	2.50	5	0	2.00	0.342	1.871			
Scissors grip Input	30	2.43	5	0	2.50	0.317	1.736	Z = −0.000	1.000	*
Scissors grip output	30	2.43	5	0	2.50	0.317	1.736			
Conical grip input	30	2.87	5	0	3.00	0.338	1.852	Z = −0.000	1.000	*
Conical grip output	30	2.87	5	0	3.00	0.338	1.852			

*Not-statistically significant p ≥ 0.05.

Table 4. Descriptive statistics of the testing grips of paretic's hand in the comparison group of patients, who completed classical kinesiotherapy.

By testing the Frenchay Arm Test, significant improvements have occurred in patients of the main group in all tasks, where the highest statistically significance was tasks 1 and 5, which resulted in a higher average output score in task 1 (Md = 1.00, SD ± 0.31) than the input score (Md = 0.00, SD ± 0.51), T = 0.00, Z(30) = −3.606, p = 0.000, r = −0.465, a higher average output score in task 5 (Md = 1.00, SD ± 0.35) compared with the input score (Md = 0.00, SD ± 0.47), T = 0.00, Z(30) = −4.123, p = 0.000, r = −0.532 (**Table 5**).

	Count	Mean	Maximum	Minimum	Median	Standard error of mean	Standard deviation	Wilcoxon signed ranks test	Asymp. sig. (two-tailed)	Effect size
Task 1 input	30	0.47	1	0	0.00	0.093	0.507	Z = −3.606	0.000	r = −0.465
Task 1 output	30	0.90	1	0	1.00	0.056	0.305			
Task 2 input	30	0.33	1	0	0.00	0.088	0.479	Z = −2.646	0.008	r = −0.342
Task 2 output	30	0.57	1	0	1.00	0.092	0.504			
Task 3 input	30	0.20	1	0	0.00	0.074	0.407	Z = −2.646	0.008	r = −0.342
Task 3 output	30	0.43	1	0	0.00	0.092	0.504			

	Count	Mean	Maximum	Minimum	Median	Standard error of mean	Standard deviation	Wilcoxon signed ranks test	Asymp. sig. (two-tailed)	Effect size
Task 4 input	30	0.13	1	0	0.00	0.063	0.346	Z = −2.236	0.025	r = −0.289
Task 4 output	30	0.30	1	0	0.00	0.085	0.466			
Task 5 input	30	0.30	1	0	0.00	0.085	0.466	Z = −4.123	0.000	r = −0.532
Task 5 input	30	0.87	1	0	1.00	0.063	0.346			

Table 5. Descriptive statistics of the testing Frenchay Arm Test in the main group of patients, who completed non-robotic therapy.

In the patients of the comparison group, improvements have not occurred of statistically significant in task of Frenchay Arm Test (**Table 6**).

	Count	Mean	Maximum	Minimum	Median	Standard error of mean	Standard deviation	Wilcoxon signed ranks test	Asymp. sig. (two-tailed)	Effect size
Task 1 input	30	0.67	1	0	1.00	0.088	0.479	Z = −1.732	0.083	*
Task 1 output	30	0.77	1	0	1.00	0.079	0.430			
Task 2 input	30	0.77	1	0	1.00	0.079	0.430	Z = −0.000	1.000	*
Task 2 output	30	0.77	1	0	1.00	0.079	0.430			
Task 3 input	30	0.43	1	0	0.00	0.092	0.504	Z = −0.000	1.000	*
Task 3 output	30	0.43	1	0	0.00	0.092	0.504			
Task 4 input	30	0.47	1	0	0.00	0.093	0.507	Z = −0.000	1.000	*
Task 4 output	30	0.47	1	0	0.00	0.093	0.507			
Task 5 input	30	0.57	1	0	1.00	0.092	0.504	Z = −0.000	1.000	*
Task 5 input	30	0.57	1	0	1.00	0.092	0.504			

*Not-statistically significant $p \geq 0.05$.

Table 6. Descriptive statistics of the testing Frenchay Arm Test in the comparison group of patients, who completed classical kinesiotherapy.

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4. Discussion

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 [11]. 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. Krebs [12] 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 – 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 assisted therapy for children with cerebral palsy. We focused on improving the range of motions in the upper extremity, improving grips of paretic hand and on testing of Frenchay Arm Test.

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 [13]. We consent, therefore, started using non-robotic Armeo® equipment in our rehabilitation center.

Lo and colleagues [14] demonstrated that the robotic system for shoulder/elbow rehabilitation on chronic post-stroke patients did not significantly improve motor performance after 12 weeks compared to usual care or intensive therapy. Nevertheless, secondary analyses showed that the robot-assisted therapy compared to usual care rather than intensive therapy improved outcomes over 36 weeks. We achieved in our clinical study statistically significant results after the completion of 20 therapies in non-robotic equipment of patients with cerebral palsy compared to the comparative group of patients who have completed classical kinesiotherapy.

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 [15]. Recent studies have demonstrated that robot-assisted therapy, in combination with new rehabilitation techniques, motivates the patient (which is very important in the case of children) and improves the treatment. A new and advanced method of feedback is the application of virtual scenarios, where the user can interact with a virtual object in real time and feels that he or she is part of a virtual environment during the therapy. Changes in cortical maps are driven by specific aspects of behavioral demand (i.e., motivation, skill acquisition) and are not simply the result of repetitive use or strength training. Virtual reality is a very attractive tool to enable the adoption of biofeedback techniques for the treatment of children with CP. In this scenario, biofeedback can be defined as the use of sensory feedback through which objective performance observation related to a specific motor task is presented to provide the child with immediate, consistent feedback of their performance. The aim of providing patients with biofeedback during exercise is twofold: first, to improve the effectiveness of the rehabilitation treatment, both by allowing patients to adjust their movements according to the feedback of performance and by providing an incentive to exercise; and second, recording the physiological parameters to be fed back to the patient, provides quantitative monitoring and documentation of the patient's progress during treatment. The latter feature is particularly important when the rehabilitation treatment is extensive and prolonged, which is typically the case with patients with CP [16]. 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. There is evidence that not only severe stressful events, but also common low-threat events, in particular chronic ones, may cause or provoke some mental disorders, especially in childhood [17]. Patient motivation is absolutely critical for successful rehabilitation after neurological injury. First, motivation in terms fun is important to maintain compliance, on a psychological level. Second, recent neuroscience research has shown that obtaining reward and challenge can enhance performance even on a deeper, neuro-physiological level [18]. A study in non-clinical populations demonstrated that depression diminishes the capability of imagining future positive outcomes and strengthens the ability to imagine negative outcomes. Patients with affective disorders also present cognitive dysfunction in areas such as working memory, attention and learning. Depression has been shown to significantly impair attention and word memory [19]. From our experience, child and adolescent patients with cerebral palsy are often depressed, especially when therapy is less effective or when progressing very slowly, we want to highlight the therapy by equipment Armeo® where we utilize motivation and cooperation of the patient, and therefore the therapy is more effective and faster.

The existing shortage of therapists and caregivers assisting physically disabled individuals at home is expected to increase and become serious problem in the near future. The patient

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population needing physical rehabilitation of the upper extremity is also constantly increasing. Robotic devices have the potential to address this problem as noted by the results of recent research studies. However, the availability of these devices in clinical settings is limited, leaving plenty of room for improvement [20]. Rehabilitation programs based on robotics adapted to the special needs of an individual user are expensive and therefore limited resources hinder the achievement of optimal therapy. Moreover, specialized technicians are needed to control the robotic technology, and this means higher costs to the family and society [16]. Despite the success of the treatment of non-robotic equipment, we are in our rehabilitation center, the only one who owns a non-robotic equipment of Armeo® in Slovak Republic.

5. Conclusion

This clinical study has achieved statistically significant results in the main group of the patients with cerebral palsy, who completed non-robotic assisted therapy compared to the comparative group of the patients who have completed classical kinesiotherapy. Therapy has improved the range of motions in the upper extremity; similarly, significant results have been shown in improvements in grip ability of paretic hand and by testing Frenchay Arm Test in the patients of the main group. The co-operation with patients during the non-robotic assisted 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 assisted therapy of Armeo® positively effects the rehabilitation of the children and adolescents with cerebral palsy. 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 we know, we can never completely get a patient with cerebral palsy back to full health, but we can help them to improve the function abilities of paretic upper extremity with interesting non-robotic assisted therapy with Armeo® equipment.

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References

[1] Riener R, Harders M. Chapter 7 – Virtual reality for rehabilitation. In Virtual Reality in Medicine. London: Springer-Verlag; 2012. p. 161–180. DOI: 10.1007/978-1-4471-4011-5

[2] Sivak S, Nosal V, Bittsansky M, Dluha J, Dobrota D, Kurca E. Type and occurrence of serious complications in patients after mild traumatic brain injury. Bratisl Med J. 2016; **117**: 22–25**.** DOI:10.4149/BLL-2016-005

[3] Dew AP, Moreau NG. Comparison of 2 techniques for measuring rectus femoris muscle thickness in cerebral palsy. Pediatr Phys Ther. 2012; **24**: 218–222. DOI: 10.1097/PEP.0b013e31825bcb77

[4] Gordon AM. What does selective motor control of the upper extremity in cerebral palsy tell us? Dev Med Child Neurol. 2016; **58**: 536–537. DOI: 10.1111/dmcn.13028

[5] Westcott MS, Yocum A, Bartlett DJ, Mendoza J, Jeffries L, Chiarello L, Palisano R. Development of the early activity scale for endurance for children with cerebral palsy. Pediatr Phys Ther. 2012; **24**: 232–240. DOI: 10.1097/PEP.0b013e31825c16f6

[6] Piña-Garza JE. Fenichel's Clinical Pediatric Neurology. 7th ed. United States of America: Elsevier Inc.; 2013. 412 p. ISBN: 978-1-4557-2376-8

[7] Hocoma. Armeo® User Manual [CD-ROM]. Switzerland: Hocoma AG; 2008.

[8] Berryman Reese N, Bandy WD. Joint Range of Motion and Muscle Length Testing. 2nd ed. United States of America: W.B. Saunders Company; 2009. 437 p. ISBN-13: 978–1416058847

[9] Kolar P, et al. Clinical Rehabilitation. 1st English ed. Praha: Alena Kobesova; 2013. 770 p. ISBN-13: 978–8090543805

[10] World Medical Association: Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Subjects [Internet]. 1964 – rev. 2000. Available from: http://www.wma.net [Accessed: 2016-06-25].

[11] Ladenheim B, Altenburger P, Cardinal R, Monterroso L, Dierks T, Mast J, Krebs HI. The effect of random or sequential presentation of targets during robot-assisted therapy on children. NeuroRehabilitation. 2013; **33**: 25–31. DOI: 10.3233/NRE-130924

[12] Krebs H, et al. Motor learning characterizes habilitation of children with hemiplegic cerebral palsy. Neurorehabil Neural Repair. 2012; **26**: 855–860. DOI: 10.1177/1545968311433427

[13] Rudhe C, Albisser U, Starkey ML, Curt A, Bolliger M. Reliability of movement workspace measurements in a passive arm orthosis used in spinal cord injury rehabilitation. J Neuroeng Rehabil. 2012; **9**: 37. DOI: 10.1186/1743-0003-9-37

[14] Lo AC, Guarino PD, Richards LG, Haselkorn JK, Wittenberg GF, et al**.** Robot-assisted therapy for long-term upper-limb impairment after stroke. N Engl J Med. 2010; **362**: 1772–1783. DOI: 10.1056/NEJMoa0911341

[15] Klobucka, S., Kralovicova, M., Ziakova, E. A functionally robot-assisted therapy upper limb. Rehabilitation and Physical Medicine. 2010; **17**: 164–168.

[16] Bayon C, Raya R, Lerma Lara S, Ramírez O, et al. Robotic therapies for children with cerebral palsy: A systematic review. Transl Biomed. 2016; **7**: 44. DOI:10.21767/2172-0479.100044

[17] Grishkina MN, Guliaeva NV, Akzhigitov RG, Gersamia AG, et al. The effect of childhood stress on the development of mental disorders in adults. Journal of Neurology and Psychiatry S S Korsakova. 2015; **115**: 16–19.

[18] Müller C. Armeo Masterclass: Learn to Motivate Your Patients More than Ever Before! Hocoma [Internet]. 2015. Available from: https://www.hocoma.com/world/en/news-and-events/news article/article/armeo-masterclass-learn-to-motivate-your-patients-more-than-ever-before/ [Accessed: 2016-07-04].

[19] Li M, Lu S, Wang G, Feng L, Fu B, Emotion NZ. Working memory, and cognitive control in patients with first-onset and previously untreated minor depressive disorders. J Int Med Res. 2016; **44**: 529–541. DOI: 10.1177/0300060516639169

[20] Maciejasz P, Eschweiler J, Gerlach-Hahn K, Jansen-Troy A, Leonhardt S. A survey on robotic devices for upper limb rehabilitation. J NeuroEng Rehabil. 2014; **11:** 3. DOI: 10.1186/1743-0003-11-3

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