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Effects of combined special education treatment and occupational therapy on upper extremities motor skills in adult patients with hemiplegia

Efekti kombinovanog somatopedskog lečenja i radne terapije na motoričke sposobnosti gornjih ekstremiteta odraslih bolesnika sa hemiplegijom

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Abstract

Background/Aim. Stroke is the most common single cause of severe and multiple physical disabilities, and rehabilitation that reduces functional deficits is the most effective treatment. The aim of this study was to determine the effect of special education treatment as a supplement to occupational therapy on upper extremities motor skills in adult patients with post stroke hemiplegia. **Methods.** Standard education tests for motor function evaluation of the upper extremities: O`Connor, Ring and Hand grip test, were applied on a sample of 64 patients who were in the process of rehabilitation in the Clinic for Rehabilitation "Dr. Miroslav Zotović" in Belgrade. After the evaluation, all the participants were included in occupational therapy and divided in two intervention groups *per* 32 subjects each. The patients from the first experimental group received individually dosed special education treatment which was performed for at least 12 weeks as a supplement together with occupational therapy, while patients from the second experimental group were only in the process of occupational therapy without special education treatment. At the end of the study the same tests were used to re-evaluate the level of motor abilities of the patients in both groups. **Results.**The patients from the first experimental group with individually dosed special education treatment as a supplement showed significantly better scores after applying the treatment in all tested variables – explosive, static and dynamic muscular strength grip fist, as well as oculomotor skills at the level of the elbow and shoulder for both healthy and paretic hand. **Conclusion.** On the basis of the obtained results, it can be concluded that special education treatment added to occupational therapy lead to better performing of upper extremities motor skills and that it can be a good supplement to conventional occupational therapy methods and techniques.

Key words:
hemiplegia; neurological rehabilitation; education, special; occupational therapy; upper extremities; adult.

Apstrakt

Uvod/Cilj. Moždani udar je najčešći pojedinačni uzrok teškog i višestrukog fizičkog invaliditeta, a rehabilitacija koja smanjuje funkcionalne deficite je najefikasnije lečenje. Cilj istraživanja bio je da se utvrdi uticaj programa specijalne obuke dodate radnoj terapiji za motoričke sposobnosti gornjih ekstremiteta kod odraslih bolelsnika sa hemiplegijom nastalom posle moždanog udara. **Metode.** Na uzorku od 64 bolesnika, koji su bili u procesu rehabilitacije u Klinici za rehabilitaciju „Dr Miroslav Zotović" u Beogradu, primenjeni su standardni somatopedski testovi za procenu motorike gornjih ekstremiteta: O`Connor, Ring i test snage stiska pesnice. Nakon procene, svi učesnici bili su uključeni u radnu terapiju i podeljeni u dve grupe po 32 ispitanika. Bolesnicima prve eksperimentalne grupe kao dopuna radnoj terapiji dodato je individualno dozirano somatopedsko lečenje u trajanju od najmanje 12 nedelja, dok su bolesnici iz druge eksperimentalne grupe bili uključeni samo u proces radne terapije bez somatopedskog lečenja. Na kraju istraživanja, isti testovi su korišćeni za ponovnu procenu nivoa motoričkih sposobnosti bolesnika iz obe grupe. **Rezultati.** Bolesnici iz eksperimentalne grupe koja je uz redovnu terapiju lečena i somatopedski pokazali su znatno bolje rezultate nakon primenjenog lečenja u svim ispitivanim varijablama – eksplozivna, statička i dinamička mišićna snaga stiska pesnice, kao i okulomotorna koordinacija na nivou lakta i ramena, kako za zdrav, tako i za paretičan ekstremitet. **Zaključak**. Na osnovu dobijenih rezultata, može se zaključiti da somatopedsko lečenje primenjeno uz radnu terapiju dovodi do poboljšanja motoričkih sposobnosti gornjih ekstremiteta i može biti dobar dodatak konvencionalnim metodama i tehnikama radne terapije.

Ključne reči:
hemiplegija; rehabilitacija, neurološka; edukacija, specijalna; radna terapija; ekstremiteti, gornji; odrasle osobe.

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Introduction

Acute stroke is defined as a focal or global disruption of brain function that occurs suddenly as the result of a cerebrovascular disorder or condition in which blood flow is not sufficient to meet the metabolic needs of the neurons for oxygen and glucose. The incidence of ischemic stroke varies and ranges from 100 to 300 new cases *per* year *per* 100,000 inhabitants, while the prevalence rate ranges from around 600 *per* 100,000 populations in developed countries, up to 900 in underdeveloped. Stroke is also the fifth leading cause of disability internationally [1–3]. Despite advances in medicine and initiatives to improve public health, the incidence of stroke is not reduced [4, 5]. According to data from the Canadian Institute for Health Information, patients who survive stroke are the largest category of users of physical rehabilitation services and the third by the length of rehabilitation (after patients with spinal cord injuries and brain dysfunction [6]. The consequences of stroke are often serious and severe, and in addition to affecting the full range of human life and functioning they also have devastating effects on family members [7], bringing the experience of stress, depression, social isolation, threatening health and rarely leading to premature death. In spite of all the researchers efforts it is not yet established the one and only, single "therapeutic cure" for motor impairments of a hand in adults with post-stroke hemiplegia. Some excellent studies in which references to the operation of both conventional (neurodevelopment therapy or "Bobath method", functional electrical stimulation, biofeedback electromyographically etc.), as well as a newer, less traditional approach (Reiki method, robotics, etc.), reported that despite the considerable efforts of researchers aimed at proving that some treatment "works", no rehabilitation intervention is not allocated and proved to be a single "cure" for recovery after stroke [8–11]. After stroke, patients must be involved in rehabilitation in the first six months, when the largest neurological and functional recovery mostly manifest. Motor impairment is the most common deficit after stroke and the major contributor to functional limitations [12]. More than 80% of individuals with stroke experience hemiparesis and of those people who initially have upper-extremity paresis, it is estimated that 70% have residual impairment. The upper limb makes a significant contribution to most activities of daily living (ADL), and impairments can compromise participation in many of these essential and meaningful tasks 13. According to another research 14, during one-year after stroke, 52% of all patients improve functional walking ability and in only 15% hand function fully recovers. It is also noted that one year after a stroke, patients with limited upper extremity function have significantly poorer image of themselves and their own recovery. Upper-limb function return has been identified as an important rehabilitation goal 12. Occupational therapists use several methods of treatment and the choice of approach depends largely on the therapist's experience and preferences. Activities are oriented towards the process of re-education and fostering the development of lost skills, while the patient is adjusting to life with certain physical, cognitive, and affective disorders. Occupational therapy treatment is aimed at preventing the development of contractures, normalization of postural tone, inhibiting abnormal patterns of posture and movement and facilitating normal postural patterns of standing upright, balance and adaptive changes in muscle tone [15, 16]. Another set of goals in occupational therapy is to achieve and establish active and voluntary control of trunk and extremities movements, volitional control of the affected hand when performing movements with the healthy arm, to establish control through shoulder and elbow flexion and extension synergy and voluntary control of rough primitive movements of the hand and fingers in capturing and releasing objects, and to combine simple movement patterns in performing complex activities of self-care together with performing daily activities using paretic hand. For patients with the plegic hand practicing compensatory function, primarily single-handed performance of bimanual training activities and practice the healthy hand to hyper function is the major task in occupational therapy [17, 18]. One approach in the treatment is teaching patients to do activities which are typically performed bimanual by with one hand. Another strategy of compensation is making changes of environment in order to reduce negative effects on the desired function of the injured limb. With the method of compensation and/or adaptation it is necessary in parallel to work on improvement of functional ability of weaker extremities [18, 19].

The aim of this study was to determine if there are any effects of combined special education treatment added to occupational therapy as a supplement to upper extremities motor skills in patients with hemiplegia who are in the process of occupational therapy.

Methods

The research was conducted during 2014/15 in occupational therapy units at the Clinic for Rehabilitation "Dr. Miroslav Zotović" in Belgrade. The research was approved by the Board of Ethical Committee of the Clinic (No.03-1908/1). All the participants were informed about the purpose of the study and signed the permission. The research was conducted in a clinical setting with the written agreement of all the included patients.

The study was conducted as a randomized controlled trial (RCT) or randomized controlled clinical trial (RCCT) – design that randomly assigns participants into experimental groups. In the RCT, an intervention is investigated by comparing one group of people who receive the intervention with the other group who does not, and the only expected difference between the groups in a randomized controlled trial is the outcome variable being studied. In this investigation both intervention groups were treated identically and received the usual occupational therapy treatment according to the protocol of the institution, but one group received special education treatment as a supplement to occupational therapy. Research conducted in this way can give an answer to practical question of whether introducing the new treatment (special education) could improve outcomes over and above the current state of practice.

Participants were chosen randomly from the groups of fully and partially hospitalized patients. The sample of patients with multiple strokes included those who were several times hospitalized at the Clinic, thus they were in a well-known environment, but there were also first time hospitalized patients. During the research from the first randomly chosen number of subjects, 8 patients were excluded because they finished rehabilitation and were discharged from the hospital and 6 subjects because they were not regular in visiting occupational therapy unit, so the final sample for the study comprised a total of 64 patients separated into two groups, 32 subjects each. Before the application of treatment both groups were equalized according to age, sex, the diagnosis and the level of motor skills. In both groups there were the equal number of men (18) and women (14), and the average age of the participants in the group who received only occupational therapy was slightly higher (63.61), compared to the group of patients who received special education exercises where the average age was 59.34 years. All the participants from both groups were prescribed occupational therapy according to the protocol of the clinic, and were included in it regularly. As a supplement to standard occupational therapy procedures, the patients from the first intervention group received a set of personalized exercises from the special education program while the patients from the second intervention group had only occupational therapy without special education exercises as a supplement.

In order to achieve the set goals first it was necessary to establish a personal card for each subject to record age, gender and the medical diagnosis. This general data were obtained from the available medical documentation. Data for dependent variables identifying the degree of motor impairment were collected by using both standard and special education evaluation methods and personal insight through appropriate diagnostic procedures. During the study the following dependent variables were examined: explosive muscular strength grip fist, static muscular strength grip fist, and dynamic muscular strength grip fist, oculomotor skills at the level of the elbow joint and oculomotor skills at the level of the shoulder. Each test was performed with both hands. Hand grip test is the test that measures explosive, static and dynamic muscular strength grip fist. Testing device consists of a pressure gauge and a rubber cuff (an apparatus for measuring blood pressure). Cuff inflates to 50 mmHg. On the verbal order patient squeezes the cuff at full power. Evaluation is done after three measurements. The average value is recorded. Explosive muscular strength was recorded as the maximum achieved numerical value expressed in mmHg. The values of static muscular strength was recorded as the time in which the respondent can maintain the achieved maximum value, while dynamic muscle strength measured time that the respondent hold his grip fist from the maximum value up to 80% of this value. Ring test measures oculomotor skilsl at the level of the shoulder joint. It consists of a rack with a stick length of 30–35 cm and 10 rings 5 times larger in diameter than the stick. A respondent has the task to put 10 rings on the stick as fast as possible. Each miss next to stick is recorded as a minus, and the total time is measured in seconds. O'Connor test also falls within the primary battery of special education tests, and it measures oculomotor skills at the level of the elbow joint. It consists of a plastic table measuring 16 × 22 cm with a large number of holes (diameters of 2.5 mm), and 10 plastic pegs (length 3.5 cm, thickness 2 mm with the head of 5 mm). The respondent has to put as fast as possible pegs in the holes. Pegs have to be placed with three fingers (thumb, index and middle finger). The time during which the respondent puts 10 pegs is measured by a stopwatch. Two attempts are allowed and better time is recorded. After evaluation each patient from the first experimental group gets his own personalized set of exercises chosen from an "open system of stimulation human development" 20. These exercises are the most common form of stimulation motor development in everyday special education clinical practice and they are conducted with the active participation of the patient and followed with vocalization. Each patient performs active psychomotor exercises on verbal instruction and if needed with demonstration by educator. In this study, exercises were from the group of exercises for stimulation the development of upper extremities general motor skills, exercises from the group for stimulating the development of coordination of movements at the level of the elbow and shoulder and from the group of exercises for stimulation the development of the power of certain movements [21]. Combined special education exercises as a supplement to occupational therapy treatment was applied to the first intervention group for 12 weeks, always at the end of each occupational therapy session, while the second intervention group was only in the process of occupational therapy. After that period participants from both groups were retested with the same tests.

The obtained data from the study were compared using two nonparametric tests – Mann-Whitney test and the Wilcoxon Signed Ranks Test. The Mann-Whitney test is used in experiments in which there are different subjects in each group, but the assumptions of parametric tests are not tenable. The Wilcoxon signed rank test has the null hypothesis that both samples are from the same population. The Wilcoxon test creates a pooled ranking of all observed differences between the two dependent measurements. It uses the standard normal distributed *z*-value to test of significance.

Data values are presented as the mean ± standard deviation and a p-value < 0.05 was considered as statistically significant. To compensate groups Student's t-test was used. Statistical analysis was performed with Statistical Package for the Social Sciences – IBM SPSS Statistics for Windows (version 15.0).

Results

The results obtained from hand grip tests are represented in Tables 1 and 2 and the results obtained from ring and O'Connor tests are quoted in the text below.

All the patients from the group who received special education exercises with occupational therapy were better in all measured variables – explosive muscular strength grip fist, static muscular strength grip fist and dynamic muscular

Table 1

Explosive, static and dynamic muscle strength grip fist (EMSGF, SMSGF and DMSGF, respectively) values for the right hand in both experimental groups before and after the treatment

Parameters	Before the treatment		After the treatment	
	SEOT group (n = 32)	OT group (n = 32)	SEOT group (n = 32)	OT group (n = 32)
EMSGF (mmHg)				
x̄ ± SD	133.53 ± 34.93	152.25 ± 32.49	239.43 ± 41.45	183.45 ± 43.32
Mann-Whitney U test	557.500		148.000	
Wilcoxon W test	1187.500		725.000	
Z	-0.673		-5.186	
p	0.501		0.000	
SMSGF (mmHg)				
x̄ ± SD	3.56 ± 1.94	3.32 ± 1.02	5.11 ± 2.00	3.59 ± 1.49
Mann-Whitney U test	533.500		245.500	
Wilcoxon W test	1163.500		800.500	
Z	-0.938		-3.412	
p	0.348		0.000	
DMSGF (mmHg)				
x̄ ± SD	5.51 ± 3.43	5.06 ± 3.83	8.88 ± 3.35	6.55 ± 4.54
Mann-Whitney U test	580.500		312.000	
Wilcoxon W test	1210.500		840.000	
Z	-0.378		-3.136	
p	0.705		0.002	

SEOT group – intervention group receiving special education and occupational therapy;
OT group – intervention group receiving occupational therapy;
x̄ – arithmetical mean; SD – standard deviation.

Table 2

Explosive, static and dynamic muscle strength grip fist (EMSGF, SMSGF and DMSGF, respectively) values for the left hand in both experimental groups before and after the treatment

Parameters	Before the treatment		After the treatment	
	SEOT group (n = 32)	OT group (n = 32)	SEOT group (n = 32)	OT group (n = 32)
EMSGF (mmHg)				
x̄ ± SD	163.86 ± 47.00	141.34 ± 36.30	222.40 ± 41.53	160.42 ± 37.45
Mann-Whitney U test	562.500		277.500	
Wilcoxon W test	1192.500		907.500	
Z	-0.605		-3.818	
p	0.545		0.000	
SMSGF (mmHg)				
x̄ ± SD	3.01 ± 1.85	2.78 ± 1.41	5.29 ± 2.00	3.02 ± 1.39
Mann-Whitney U test	508.500		241.000	
Wilcoxon W test	1138.500		913.000	
Z	-1.225		-4.262	
p	0.220		0.000	
DMSGF (mmHg)				
x̄ ± SD	4.39 ± 4.94	4.13 ± 4.48	7.13 ± 3.84	4.97 ± 4.95
Mann-Whitney U test	557.500		312.000	
Wilcoxon W test	1187.500		840.000	
Z	-0.673		-3.136	
p	0.501		0.002	

SEOT group – intervention group receiving special education and occupational therapy;
OT group – intervention group receiving occupational therapy;
x̄ – arithmetical mean; SD – standard deviation.

strength grip fist for both hands in hand grip test evaluation after the applied treatment. Achieved greater muscle strength of grip fist led to less errors and misses in catching and releasing rings while putting them on a stick during the execution performing the tasks from the test. The patients were also more accurate and finger movements were more refined in the act of holding rings (ring test) and in holding plastic pegs while putting them into holes (O'Connor test).

The results of the ring test which measures oculomotor skill at the level of shoulder for the right hand showed that the first intervention group which received special education exercises improved highly statistically significantly after the treatment compared to the second intervention group ($p = 0.000$), whereas before treatment both groups were equal ($p = 0.294$). The ring test for the left hand also showed differences between the groups on the basis of which it was proved that the experimental group which received special education exercises highly statistically significantly improved after the treatment ($p = 0.000$) compared to the experimental group without exercises, while before the treatment both groups were equal ($p = 0.438$).

The results obtained in the O'Connor test which tested oculomotor skill at the level of elbow joint for right hand showed that the experimental group which received special education exercises improved highly statistically significantly after the treatment compared to the second intervention group which received only occupational therapy activities ($p = 0.000$), whereas before the treatment the two groups were equalized ($p = 0.668$). A statistical analysis in the O'Connor test for the left hand showed statistically significance differences between the intervention groups. The first experimental group improved highly statistically significantly after the treatment compared to the second experimental group which received only occupational therapy activities ($p = 0.000$), while before the treatment both groups were equal ($p = 0.321$).

The results showed a statistically significant improvement in the first experimental group of patients who were at different levels of progress in all tested variables of motor abilities, after the applied treatment, while participants in the second experimental group who received only occupational therapy activities had no such progress. The results of a repetitive upper extremity special education therapy program as a supplement to occupational therapy during inpatient rehabilitation resulted in a greater improvement in upper limb function in the group of patients who received special education exercises as a supplement to occupational therapy, than in the group who received only occupational therapy activities and this improvement showed a better voluntary arm control while performing movements in the shoulder and elbow that were required for the evaluation. Voluntary arm movements while performing shoulder flexion during the act of putting rings on a stick were made easier, smoother and faster. Although, it was not the subject of this study and therefore not recorded, attempts that all participants from the intervention group who received special education exercises made to re-establish the lost functions were not manifested only through physical efforts performed during the exercises, but they also invested a great amount of psychological effort, and each movement was strongly supported by their hopes and expectations. Even before the expiration of stipulated 12 weeks, while the special education treatment was still going on, more than half of the patients from this group reported better self confidence and felt more assertive while performing customary activities (particularly dressing and undressing).

Discussion

The obtained results are in accordance with other findings in the literature. Repeated motor activity (even very simple movements) is the basis of motor learning and recovery by causing changes in the cortex. For upper extremity motor training, the patients engaged in the task-specific activities usually achieve significantly greater gains compared to those who perform simple movements [22]. This would mean that constant repetition of practical tasks (direct and repeated training) as an alternative means of exercise can produce cortical changes that lead to improvement of functions. Ma and Trombly [23] argue that doing movements to achieve a certain objective during practical tasks can improve coordination and increase the range of motion. Most of the newer theories in the rehabilitation of stroke patients are based at least to some extent on the theory of motor learning [24]. Special education activities combined with individual exercise program and somatosensory stimulation in the form of repeated peripheral nerve stimulation, proved to be more effective in the chronic phase of recovery from stroke and in terms of improving the use of paretic hand in the Jebsen-Taylor test 25, 26. Another study confirmed that repeated exercises through the open and closed kinetic chain, with patients educated during rehabilitation, lead to the strengthening of extremity muscle strength and improve the balance in patients with stroke in the chronic phase of recovery, and was also a good predictor of functional recovery 27. On the contrary, French et al. 28 show that results of some studies prove that repetition of practical tasks in combination with intense exercise has no influence on the function of the upper extremities in patients with stroke, but slightly improved performance in activities of daily living. Some authors claim that hemiparetic upper extremities can increase strength and speed when a patient include self-vocalization while performing familiar motor tasks commonly used in occupational therapy 29. They also recommend organizing therapy sessions that simultaneously restore the speech and hand motor control that are so often impaired by stroke. Ostry et al. 30 identified the correspondence in the forms for speed hand movements and speech movements and suggested that the hand and speech can use the same elements of the motor programming. Neuroimaging observes that cortical motor area for programming speech, Broca's area, shows neurocortical activation during movements of the hand and wrist, and the same was observed when respondents are only imagined to perform the movement 29. Taking into account previous researches in this area, it is possible that repeated constant activation of Broca`s area in the execution of motor task can promote plasticity and lead to lasting improvements.

Limitations of the study and implications for practice

Although the obtained results show that the patients from the intervention group who received special education exercises achieved greater muscle grip strength and better coordination of upper extremities at the level of the elbow and the shoulder, the results must be interpreted with caution due to: relatively small sample, and almost perfect clinical settings in occupational therapy units provided at the Clinic for Rehabilitation "Dr. Miroslav Zotović" (the oldest rehabilitation center in Serbia with powerful tradition in rehabilitation people with post stroke hemiplegia). Therefore, the replication of the study with a larger sample and in different rehabilitation units is required. Also, the study lacks generalization in greater view. Because of the fact that each patient got personalized support through special education exercises that were added to standard occupational therapy treatment, thereby the duration of each therapy session extended, thus demanding more medical staff. Besides that, in the research there were no patients with a plegic (nonfunctional) hand who usually represent the major number of rehabilitation service users. It should be also acknowledged that only a limited number of arm movements were considered in this study, particularly when taking into account the complexity and numerous movements of the hand and fingers performed in the act of capturing and releasing different objects. And finally, after achieving greater muscle strength and increased mobility in the shoulder and the elbow joint, hand functions were not explored through object manipulation, neither patient's functional ability to use the paretic hand in everyday activities was further researched. Even though it was not an objective of this study, we consider it the greatest limitation of future implementation of special education exercises in clinical practice, because for each person it is more important what he/she can do with the hand than the numerical score obtained in test situation.

Conclusion

Patients with post-stroke conditions in a subacute phase of recovery have great potentials and they represent a group that is most likely to benefit from every intervention aimed at maximizing functional recovery. Therefore, further research in this area with a larger number of patients and in different institutions for rehabilitation is recommended and should be directed towards identifying instances of good practice.

For now, according to all the results obtained in this study it can be concluded that the aim of the research was fulfilled and the assumption confirmed that special education treatment as a supplement to occupational therapy activities have effects on improving upper extremities motor skills in adult patients with post-stroke hemiplegia included in the process of rehabilitation.

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