EFFECT OF THE APPLICATION OF CONSTRAINT-INDUCED MOVEMENT THERAPY ON THE RECOVERY OF AFFECTED HAND FUNCTION AFTER STROKE

Dalia Mickevičienė, Justina Butkutė, Albertas Skurvydas, Diana Karanauskienė, Mantas Mickevičius
Lithuanian Sports University, Kaunas, Lithuania

ABSTRACT

Background. Research aim was to evaluate the effect of the application of constraint-induced movement therapy on the recovery of affected hand function after stroke. Research hypothesis: The application of constraint-induced movement therapy on the recovery of affected hand function after stroke would be more effective than the application of conventional physiotherapy.

Methods. The study employed the Mini Mental State Examination (MMSE), Lovett's test, Modified Movement Assessment Scale (MMAS) hydraulic dynamometer, and Wolf Motor Function Test.

Results. Results showed that constraint – induced movement therapy for patients after stroke helps to recover injured hand movement more effectively ($p < .05$), enhances performance of functional tasks ($p < .05$) and also increases muscle strength ($p < .05$) compared to conventional physiotherapy.

Conclusions. After the application of the conventional physiotherapy for patients after stroke affected hand movements and functional task performance improved and the hand grip strength increased statistically significantly. Applying the constraint-induced movement therapy for patients after stroke affected hand movements and functional task performance improved and the hand grip strength increased statistically significantly. The application of constraint-induced movement therapy for patients after stroke statistically significantly more improved the affected hand function than the application of conventional physiotherapy.

Keywords: constraint-induced movement therapy, stroke, hand function, rehabilitation, physiotherapy.

INTRODUCTION

Brain damage is one of the most common and serious injuries, and the elimination of its effects is a long, complex and expensive process (Bižokaitė & Daratienė, 2011). According to the research data, 20% of patients die from stroke, more than 50% of stroke survivors remain temporarily or permanently disabled, only 20% of working-age people return to work, and about 10% of patients are in need of nursing (Jamontaitė & Puzara, 2011).

Approximately 43 to 69% of patients who have suffered a stroke, have problems with their hand movements, and four years after the disease, impaired hand function and its restriction remains a major problem in patients (Siebers, Öberg, & Skargren, 2010). The most common consequence of stroke is paralysis which disrupts movements. There are two broad types of paralysis: hemiparesis and hemiplegia. Statistics show that after stroke hemiplegia occurs in 11.2%, severe hemiparesis – in 11.1%, and mild hemiparesis – in 58.9% of patients (Dewey, Chambers, & Donna, 2004).

Hands function is one of the most important components of the quality of life. Hands can help us manipulate with objects in different environments, so the arm function recovery is of great importance. There are many scientific articles that explore the upper extremity disorders and its restoration after

stroke. There are a variety of physical therapy techniques, the latest technology tools which speed up the recovery of the affected arm. One of the techniques applied is training movements using various computer programmes (Cameirao, Bermundez, & Verschure, 2008), creating a "virtual reality" model (Subramanian et al., 2007) and electrical muscle stimulation (Lindquist et al., 2007).

Most physiotherapy methodologies used in patients after stroke tend to compensate the impaired function and ensure the recovery of independence in daily life. Patients are taught to use the undamaged hand and various compensatory measures, while the purpose of constraint-induced movement therapy is maximum return of hand functions or improvement of existing functions in damaged hands (Dromeric, Edwards, & Hahn, 2000).

Constraint-induced therapy is a neurorehabilitation technique that improves motor function in the affected arm after stroke (Alberts, Butler, & Wolf, 2004). Traditional constraint-induced therapy programme consists of intensive motor training, repetitive and adaptive tasks for the affected limb, while the healthy arm is constrained by a glove or a special splint.

Timely and proactive rehabilitation measures improve prognosis of the disease, help restore damaged functions, prevent complications, and give the patient a chance to adapt in daily activities (Šapogienė, Strukčinskienė, Raistenskis, Griškonis, & Stasiuvienė, 2011). Physiotherapy plays an important role in rehabilitation of patients after stroke (Kwakkel, 2006). Studies comparing the early and late start of rehabilitation have shown that a better prognosis is provided by the therapy which starts within 20–30 days (Jatužis & Kasiulevičius, 2010). Therefore, the early start of rehabilitation is an essential component of treatment in a specialized stroke section.

Research hypothesis poses that the application of constraint-induced movement therapy is more efficient than conventional physiotherapy aiming at recovering the function of the affected hand after stroke. **Research aim** was to evaluate the effect of the application of constraint-induced movement therapy on the recovery of affected hand function after stroke.

METHODS

Subjects. Research was carried out in PI Palanga Rehabilitation Hospital, Department of Neurology in 2013. The patients participated in the research voluntarily. They were acquainted with the research aims, procedures and possible inconveniences. The study was conducted in accordance with the principles of the Declaration of Helsinki dealing with the ethics of the experiments with human beings.

The study involved 20 patients (11 men and 9 women). All persons selected were after the ischemic stroke regardless of the damaged left or right hand. Inclusion criteria were as follows:

- No more than six months after strike;
- Muscle strength of the damaged hand according to Lovett's 5-point scale is no less than 2 points;
- Ability to understand orders and the essence of training is no less than 11 points in the Mini Mental State Examination (MMSE);
- Ability to stretch the hand at the elbow joint at least 20°, and the fingers of the hand – 10° (goniometry);
- Muscle spasticity according to Ashworth scale 0–1 points.

Patients subjects with underlying medical conditions that could affect the test results (e.g. amputations, muscular atrophy) were not included in the study.

Subjects were randomly assigned to experimental and control groups with 10 patients in each of them. The experimental group included 5 men and 5 women, the control group had 6 men and 4 women. Their characteristics are given in the Table. Patients in the experimental group underwent constraint-induced movement therapy, and those in the control group – conventional physiotherapy.

Table. **Characteristics of subjects (mean ± *SD)***

Characteristics	Subjects	
	Control group	Experimental group
Age *(m)*	68.90 ± 2.81	68.7 ± 2.95
Height *(cm)*	168.50 ± 5.68	166.20 ± 4.96
Weight *(kg)*	75.20 ± 5.27	73.40 ± 5.15
Duration of the disease *(years)*	3.44 ± 1.07	3.20 ± 1.03

Methods applied. First the patients took the *Mini Mental State Examination*, (MMSE), a structured method to test cognitive (cognitive) function which is widely used in clinical practice (Mungas, 1991).The minimal score is 0, maximal – 30. Less than 20 points means deterioration of cognitive function (Folstein, Folstein, & McHugh,

1975). Lovett's test was used to assess muscle strength from 0 – absence of muscle contraction, to 5 – active movement overcoming constraint (Krutulytė, 1999). Hand function was assessed using *Modified Movement Assessment Scale* – MMAS) (Carr & Shepard, 2003). The present study employed a modified version of the scale which aimed at evaluating changes related to the recovery of function and the reliability of the method applied (Williams, Galea, & Winter, 2001). Muscle strength of the damaged hand was measured using hydraulic dynamometer. This device shows the maximum grip strength (0–90 kg).

The effect of constraint-induced movement therapy is most often assessed using *Wolf Motor Function Test* (Wolf et al., 2006). It is also one of the most commonly used assessment methods in rehabilitation of patients following a stroke. The test establishes the possibilities of the upper limb movements within a certain period of time, measuring movements in one or more joints and functional task performance (Fritz et al., 2006). It starts with easy tasks such as laying hands on the table, and then the tasks become more difficult, such as turning over pictures or picking up paper clips. The tasks should be carried out in no less than 120 s. The maximal score in the test is 75, the minimal score is 0.

Organization. All subjects were tested before and after rehabilitation procedures and the results obtained were compared. During the procedures, the patients were motivated to try to achieve better results. The control group underwent conventional physiotherapy five times a week, 30–45 min a day. Every patient attended 10 physiotherapy sessions. The experimental group had constraint-induced movement therapy. A special glove was used to restrain the healthy arm movements so that the upper arm and the forearm could not participate in the activities. The patients had to wear this device 6 hours a day during the most active hours, regardless of the patients' condition and well-being. The total workout lasted for 2 weeks, 5 days a week. Every hour the patients had a 10–15 min break when they could take off the glove. Training involved the exercises to restore the function only of the affected hand constraining the healthy hand.

During the session various movements were carried out: reaching, grabbing, pinching, lifting, putting, pushing (e.g. laying out pins, hanging rings, picking up small items), physical exercise, work and daily activities, etc. Task difficulty was gradually increased: in the beginning the patients only had to perform the movement, but then they had to reach further, lift higher, or repeat more times (Figure 1).

Figure 1. **A task in constraint-induced movement therapy**

Mathematical statistics. Research data were processed using *Microsoft ® Excel 2003* programme package. We calculated the mean values ($\bar{x}$) and standard deviations (*SD*) of the investigated indices. The significance of differences of the results for functional movements of the affected hand and hand muscle strength before and after the application of constraint-induced movement therapy was calculated using Students *t* test for paired samples. The significance level was set at $p < .05$.

RESULTS

Analysis of the results of the Modified Movement Assessment Scale. During the first testing of patients, i.e. before physiotherapy, hand movements in the control group were assessed by 27.87 ± 0.8 points, and in the experimental group – 27.95 ± 0.83 points. During the retest after two weeks it was found that the mean value of task performance in the control group was 32.55 ± 0.69 points; in the experimental group it was 34.65 ± 0.82 points. The maximum score in the Modified Movement Assessment Scale is 72 points. After treatment (conventional physiotherapy and constraint-induced movement therapy) there was a statistically significant recovery of hand movements. Comparing the two methods of treatment we suggest patients who received constraint-induced movement therapy showed better results (Figure 2).

Analysing the mean values of hand movements in a complex task we did not find significant differences in both groups before physiotherapy: in

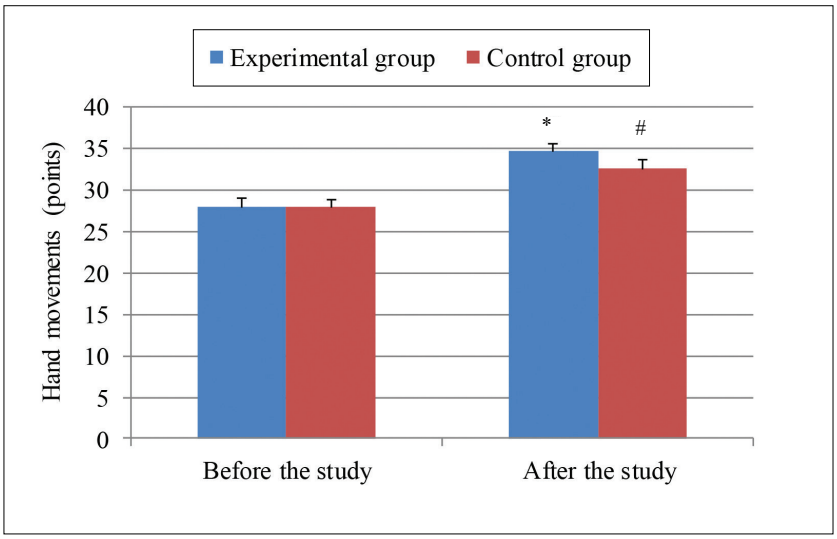
the control group it was 20.88 ± 1.71 points, in the experimental group – 20.95 ± 1.3 points. After the repeated assessment of subjects after physiotherapy it was established that the mean value in the control group increased to 23.86 ± 1.1 points, and in the experimental group – 31.1 ± 1.02 points (Figure 3). Complex hand movements improved statistically significantly.

Comparing the Modified Movement Assessment Scale (MMAS) results after the application of two different physiotherapy methods we see that for patients who had constraint-induced movement therapy hand recovery increased from 48.90 ± 2.07 to 65.77 ± 1.35 points, and for those who had conventional physiotherapy – from 48.75 ± 1.66 to 57.21 ± 1.40 points (Figure 5). The evaluation of the effect of both physiotherapy methods on hand movement recovery revealed statistically significant differences.

Comparison of the results of Wolf Motor Function Test. Before the programme applied the results for patients were similar: in the control group – 49.4 ± 1.30 points, in the experimental group – 49.1 ± 1.90 points. Research results showed that in the experimental group the score in Wolf Motor Function Test after the constraint-induced movement therapy increased to 69.70 ± 1.1 points, and in the control group which had conventional physiotherapy – to 61.2 ± 2.00 (Figure 5). The difference between the results of those two physiotherapy methods was statistically significant.

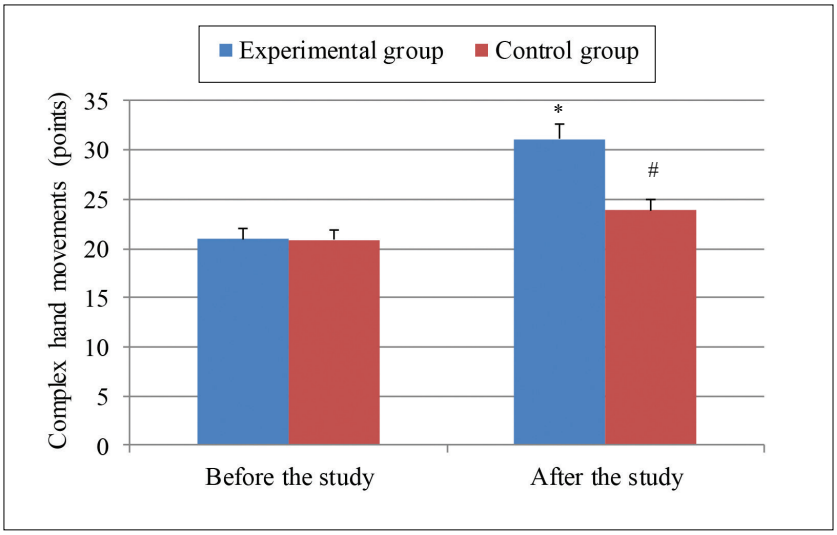
Analysis of hand-grip strength results. In the experimental group the mean value of hand-grip strength before the application of constraint-induced

Figure 2. **Changes in hand movements (according to Modified Movement Assessment Scale) before and after the study**



Notes. * – significance of mean differences ($p < .05$) comparing the values before and after the study; # – significance of mean differences ($p < .05$) comparing the values in the control and experimental groups after the study.

Figure 3. **Changes in complex hand movements (according to Modified Movement Assessment Scale) before and after the study**



Notes. * – significance of mean differences ($p < .05$) comparing the values before and after the study; # – significance of mean differences ($p < .05$) comparing the values in the control and experimental groups after the study.

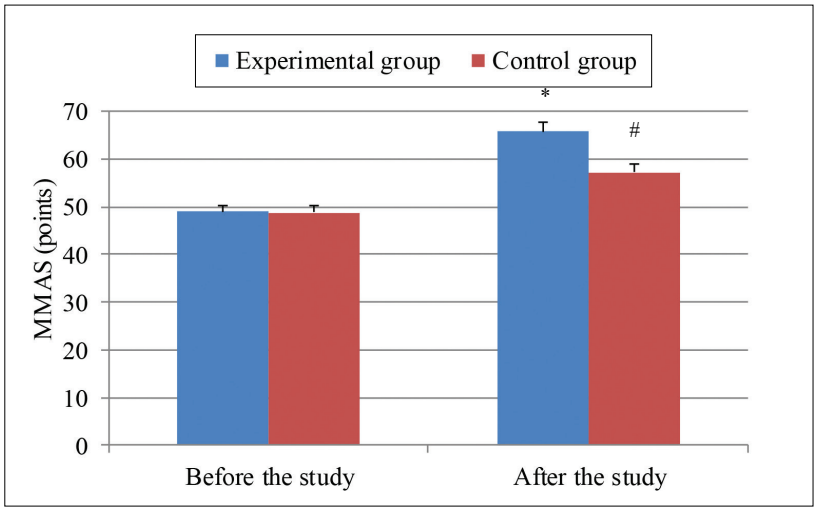


Figure 4. **Changes in Modified Movement Assessment Scale (MMAS) results before and after the study**

Notes. * – significance of mean differences ($p < .05$) comparing the values before and after the study; # – significance of mean differences ($p < .05$) comparing the values in the control and experimental groups after the study.

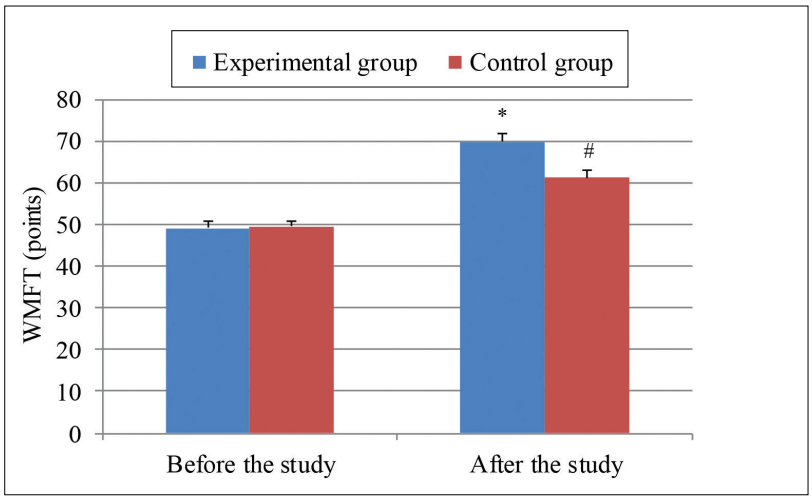


Figure 5. **Comparison in changes in Wolf Motor Function Test (WMFT) results after the application of constraint-induced movement therapy in the experimental group and conventional therapy in the control group**

Notes. * – significance of mean differences ($p < .05$) comparing the values before and after the study; # – significance of mean differences ($p < .05$) comparing the values in the control and experimental groups after the study.

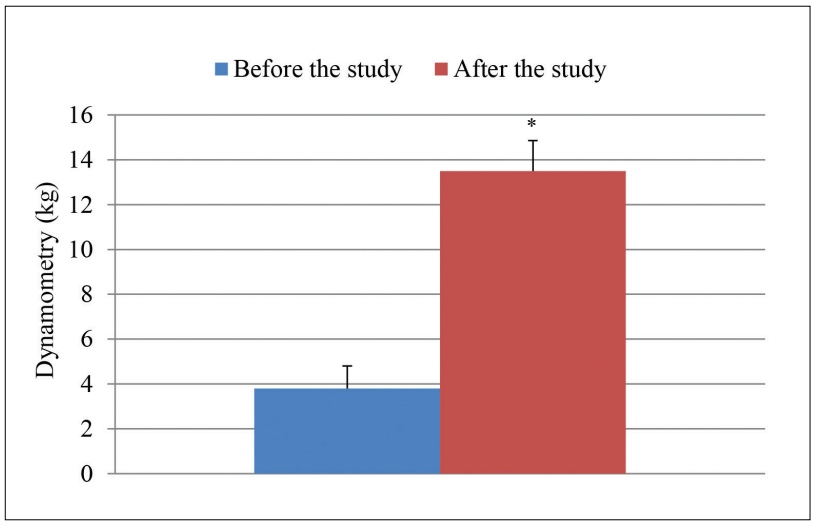


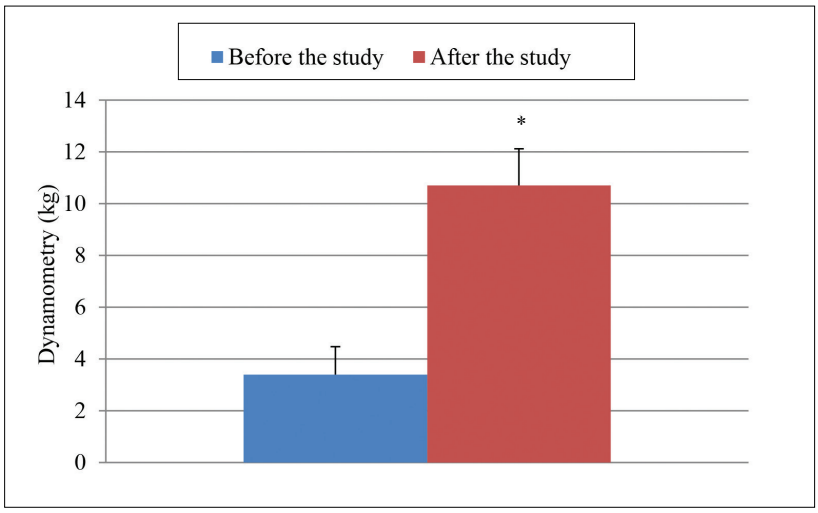
Figure 6. **Changes in hand-grip strength for patients before and after constraint-induced movement therapy**

Note. * $p < .05$, comparing the values before and after constraint-induced movement therapy.

movement therapy was 3.8 ± 1.32 kg. after the therapy the strength of hand muscles increased by 9.1 kg (13.5 ± 1.35) ($p < .05$) (Figure 6).

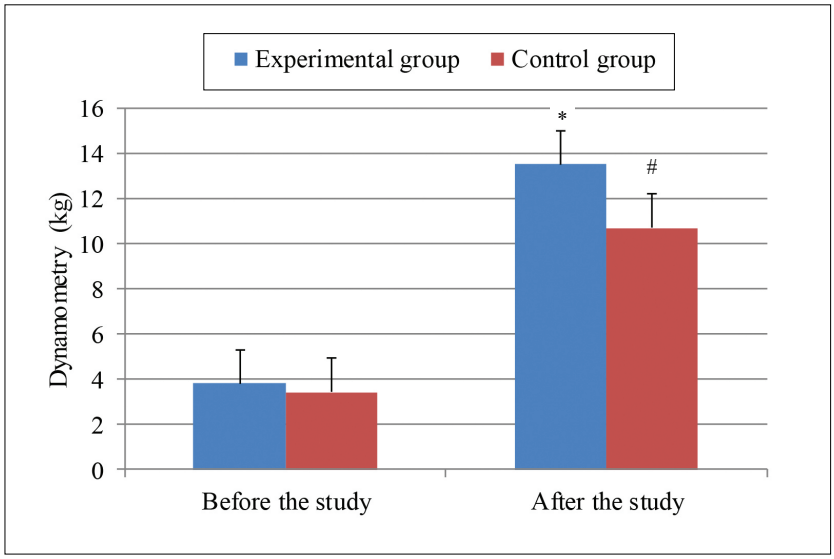
In the control group, hand grip strength before the conventional physiotherapy was 3.4 ± 1.07 kg. After the repeated assessment after exercising, the strength of hand muscles increased by 7 kg on average (10.7 ± 1.42) ($p < .05$) (Figure 7). Patients who had constraint-induced movement therapy increased their hand muscle strength by 2.8 kg more than those who had conventional physiotherapy ($p < .05$) (Figure 8).

Figure 7. **Changes in hand-grip strength for patients before and after conventional physiotherapy**



Note. *p < .05, comparing the values before and after conventional physiotherapy.

Figure 8. **Changes in hand-grip strength after the application of constraint-induced movement therapy and conventional physiotherapy**



Notes. * – significance of mean differences (p < .05) comparing the values before and after the study; # – significance of mean differences (p < .05) comparing the values in the control and experimental groups after the study.

DISCUSSION

Research aim was to compare the efficiency of physiotherapies (constraint-induced and conventional) on the recovery of impaired hand function. It has been established that constraint-induced movement therapy produced better results than conventional physiotherapy. Similar results were obtained by Alberts et al. (2004), who found that a two-week constraint-induced movement therapy for patients who had stroke 3–9 months before produced significant improvement of hand function. Besides, improved hand function remains about one year after therapy (Wolf et al., 2006).

Constraint-induced movement therapy more improves impaired hand function for patients after stroke, which is very important for their independence (Miklaševičienė, Jamontaitė, & Raistenskis, 2012). Similar statistically significant results were obtained by Brogardh and Sjolund (2006), who found that a two-week constraint-induced movement therapy can help patients restore their hand function even in the late period after stroke.

Comparing the constraint-induced movement therapy with conventional physiotherapy we suggest that the first one is more effective than alternative therapies for patients after stroke. Research by Williams, Colton, Fregni, Leone-Pascual, and Alexander (2009) came to the same conclusion. Constraint-induced movement therapy is an effective method for treating long-term hand function impairment.

Azab et al. (2009) showed that a four-week constraint-induced movement therapy together with traditional therapies for patients after stroke produced a statistically significant improvement. It remained after even six months, as it was shown

by the testing results. It has proved once again that constraint-induced movement therapy is a perspective and efficient method of rehabilitation for long-term movement function impairment after stroke.

Similar results were obtained by Wang, Zhao, Zhu, Li, & Meng (2011). They compared conventional, intensive conventional and constraint-induced movement therapies. After two weeks of treatment, Wolf Motor Function Test results showed the greater efficiency of intensive conventional and constraint-induced movement therapies. However, Wang et al. suggest that constraint-induced therapy is the most effective comparing all three methods because the application of it produced strong, systemic and statistically significant relations between the initial values and those obtained after two – four weeks of treatment.

The essence of constraint-induced movement therapy is the performance of complex and accurate movements, which requires hand muscle strength. Siebers et al. (2010) found significant improvement in the hand-grip strength in their research. Porter and Lords (2004) found different results in the application of Modified Movement Assessment Scale, but the differences can be explained by the duration of treatment: in our study the treatment was one week longer compared to that in the study of aforementioned researchers.

Our research has confirmed the hypothesis that that the application of constraint-induced movement therapy is more efficient than conventional physiotherapy aiming at recovering the function of the affected hand after stroke.

CONCLUSIONS

1. The application of conventional physiotherapy for patients after stroke significantly improves hand movements and the performance of functional tasks, and increases the hand-grip strength of the affected hand.
2. The application of constrained-induced movement therapy for patients after stroke significantly improves hand movements and the performance of functional tasks, and increases the hand-grip strength of the affected hand.
3. Constrained-induced movement therapy is more effective for patients after stroke, and it more improves the function of the affected hand compared to conventional physiotherapy.

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Corresponding author **Dalia Mickevičienė**
Lithuanian Sports University
Sporto str. 6, LT-44221 Kaunas
Lithuania
Tel. +370 37 302636
E-mail dalia.mickeviciene@lsu.lt