THE ASSESSMENT OF THE EXTENT OF THE RECOVERY OF HAND SENSORIMOTOR FUNCTIONS IN THE GROUP OF REHABILITATED PATIENTS AFTER STROKE IN THE POST-ACUTE STAGE

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Submitted in September, 2009

BACKGROUND: Although the deficit of hand sensomotory functions is very common in patients after stroke, the algorithm of their renewal is relatively little known. It is not clear whether the extent or type of somatosensory dysfunction correlates with an impeded process of motorics renewal.

OBJECTIVE: This study was focused on observation of hand sensorimotor functions in a group of patients in post-acute phase after ischemic stroke, localized in artery cerebri media. The aim was to find out the extent of improvement of somatosensory and motor hand functions. This is the first stage of a research project which will be followed by the observation of an experimental group with therapy targeted to somatosensory functions.

METHODS: The observed group of patients was treated at an inpatient department of a rehabilitation clinic and underwent standard therapy lasting 3–4 weeks. To assess hand sensorimotor functions two sensation tests were used: the FMT – the Fabric Matching Test and the RASP – The Rivermead Assessment of Somatosensory Performance. Two tests of fine motor function were also used: the NHPT – The Nine Hole Peg Test and the TMF – The Test of Manipulation Functions by means of a special constructional set Ministav. These tests were performed at the beginning and at the end of therapy.

RESULTS: In the observed group of patients, we found impairments of somatosensory functions and fine motor function even on the unimpaired upper limb. Nevertheless, fine motor function is impaired more seriously than the somatosensory functions. The biggest deficits of motor functions were found in tasks which had required a precise grip. The most obvious changes in the assessment of patients were found in ADL assessed by the Barthel Index – the return of functions towards the standard was observed in one third of the subjects.

CONCLUSION: After the application of standard therapy, improvement of hand sensorimotor functions was observed in a group of patients, but the results are not consistent. Some of the patients got worse and sometimes there was only a slight change. The results of an experimental group of patients must be proven by a therapy specifically targeted to influence the somatosensory functions.

Keywords: Stroke, hand with hemiparesis, somatosensory functions, fine motor functions, hand functions tests.

INTRODUCTION

With regards to patients after stroke, the impairment of sensorimotor functions is shown in more than 65% of patients in their set of symptoms. The most characteristic symptom is the loss of discriminative sensation. The tresholds of the primary sensory quality (e.g. touch) are often unidentifiable and some qualitative changes, variability in responses and dissociated loss of sensation, are observed. The important role of sensation in motor function is particularly evident in their control of pinch grip, their ability to sustain and adapt appropriate force without vision, object manipulation, combining component parts of movement such as transport and grasp, discrimination of surfaces at the end of handheld objects, and adjustment to sensory conflict conditions such as a rough surface (Selzer et al., 2006).

Furthermore, the sensory impairments have detrimental effects on the spontaneous use of hands and influence the reacquisition of skilled movements. It has been suggested that a learned non use phenomenon, occuring with sensory loss, leads to further deterioration of motor abilities (Dannenbaum & Dykes, 1988). Despite this fact, these impairments and their recovery when performing diagnostics are often omitted. The present time studies mostly focus only on the evaluation of the recovery of impaired motor functions.

Some authors suggest that it is not necessary to follow somatosensory functions to predict the recovery of impaired functions, and that it is problematic to evaluate them objectively. Nevertheless there exists an opinion that, despite the importance of sensation, there is no standardized assessment procedure or consistent method of recording findings (Lincoln et al., 1991). Other

authors are opposed and, contrary to this opinion, suggest that it is necessary to follow these functions and register their changes (Campbell et al., 1996; Carey et al., 2002; Blennerhassett et al., 2006).

The importance of the sensory system as an early indicator of motor recovery after stroke has been suggested in neuroimaging and clinical studies (Kusoffsky et al., 1982). It has been suggested that sensory reorganization may precede motor reorganization and may, in fact, trigger the latter (Weiller, 1998).

At present, relatively little is known about the time or pattern of recovery for somatosensory loss after stroke or whether the extent or type of somatosensory loss by itself is associated with poor motor or functional recovery (Winward, 2007).

This study is aimed at the extent of the recovery of somatosensoric and motoric functions of the hand in patients after stroke using four tests and the results received are compared with the results of a one Activity of Daily Living test.

METHODS

The study was comprised of 15 patients (7 men, 8 women) who suffered from ischemic middle cerebral artery stroke in the postacute phase. All were right handed. They were observed at the age of 45–75 years (mean 59.6 years), 11 with left and 4 with right hemiparesis. Reasons for excluding patients included: unable to cooperate, severe speech disorders, neglect syndrome and peripheral neuropathy.

A limit of the study is the interrelationship between the trunk posture and the limbs. A possible limitation is also the influence of diagnostics and therapy in the case of other clinical signs. Therefore other output variables, such as changed muscle tone, muscle length and occurence of spasticity, which will not be included in the study, will have to be considered when evaluating its outcome. This study was approved by the Faculty Hospital Ethics Committee.

The study participants were investigated for somatosensory and motor recovery in the post-acute phase after their stroke at the Clinic of Rehabilitation, Faculty Hospital Ostrava. They were assessed twice,, right from the start (check up) and also at the end (e.g. examination) of their rehabilitation. During their stay at the Clinic of Rehabilitation, standard rehabilitation was performed, including physical therapy and neurorehabilitation techniques within the framework of physiotherapy and occupational therapy. Rehabilitation was performed on average five times a week, twice a day (approximately 7. 5 hours per week), for four weeks.

In all subjects, to assess their sensorimotor functions, four tests were used. Two of these tests were somatosensory tests: FMT – The Fabric Matching Test (Carey et al., 1997) and RASP – The Rivermead Assessment of Somatosensory Performance (Winward et al., 2000), and two tests were motor function tests: NPHT – The Nine Peg Hole Test (Wade, 1994; Mathiowetz et al., 1985) and TMF – The Test of Manipulation Functions (Vyskotová et al., 2003; Vyskotová, 2007). Further, one ADL test – Barthel Index (Mahoney, 1965) – was performed – TABLE 1.

TABLE 1
Used tests

Title of the test	**Test characteristics**
FMT (The Fabric Matching Test)	Test for assessing sense discrimination focused on fabric surface. It consists of a set of ten standardized fabric surfaces, which range on a scale from the softest to the roughest. The goal is to distinguish the variety and to assign the same surfaces matching each other. The achieved score served as the test criterion.
RASP (The Rivermead Assessment of Somatosensory Performance)	Test for assessing somatosensory functions in neurological diseases. It contains seven subtests: sharp/dull discrimination, surface pressure touch, surface localization, bilateral touch discrimination, two point discrimination, temperature discrimination, proprioception movement discrimination, proprioception direction discrimination. The achieved score served as the test criterion.
NHPT (The Nine Hole Peg Test)	Test for assessing fine motor function. The patient's task is to place, as quickly as possible, nine pegs into holes in a testing board and then to pick them up with one hand, one peg after another, and to put them into a bowl. Unimanual dexterity of the fingers is tested. The achieved time is used as the test criterion.
TMF (The Test of Manipulation Functions)	The test assesses handling skills, unimanual and bimanual, by means of five objects of the special constructional set Ministav, which are called *The needle*, *The cube*, *The house*, *The pyramid* and *The mummy*. As a whole, it comprises 17 subtests, in which tasks such as assembling and dismantling of objects, assembling of an object according to the example, upholding with the palmar and pinch grasp or putting the needle through holes into the object are performed. The achieved time is used as the test criterion.
Barthel Index	Standard, well validated assessment that measures functional outcome, including independence in mobility and self care. The Barthel Index consists of 10 items (feeding, bathing, grooming, dressing, bowels, bladder, toilet use, transfers, mobility and stairs). The achieved score served as the test criterion.

Statistics were not done due to the limited number of patients. For better plasticity, the outcome is demonstrated in a summarized form of the column graph in order to differentiate the changes in particular items and their trends clearly and in order to manifest the abnormal findings in "unimpaired" limbs in patients after stroke in a better way.

RESULTS

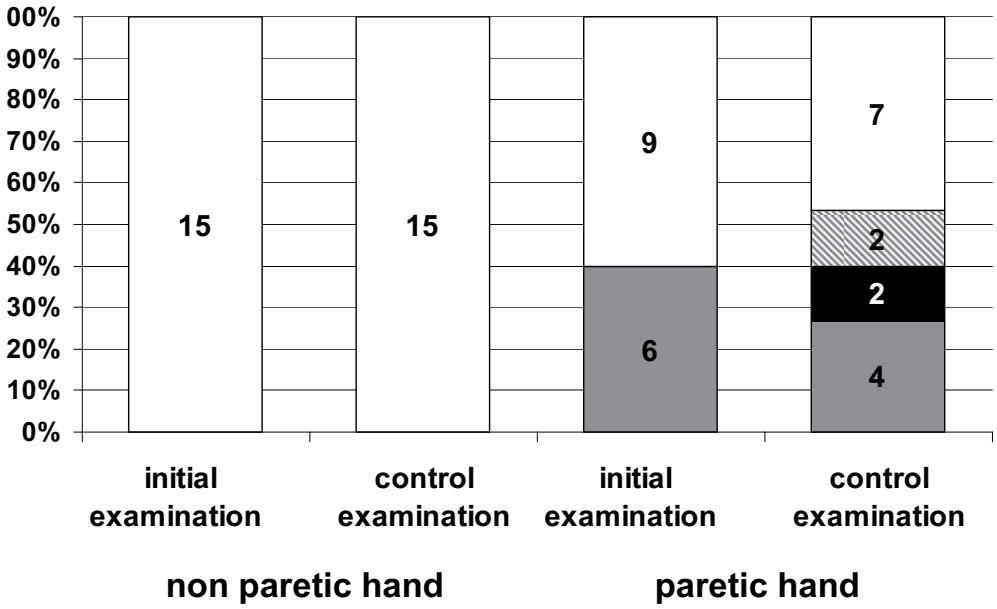
In all subjects the results of the initial check-up and final examination have been given. We have assessed how many subjects, according to the given standards for single tests, were within the standard or did not reach the standard during testing. Furthermore, some improvements and deteriorations in performance were observed during the final examination. The results are shown in the graphic form by means of the bar graphs. In these graphs the following categories are shown:

- **standard** (number of subjects having no deficit);
- **improvement** (number of subjects showing improvement after therapy);
- **deterioration** (number of subjects whose states were observed to be worse at the final examination);
- **off the standard** (a number of subjects who were not up to the standard of the given tests and were not influenced by therapy).

The results of somatosensory tests are different in single tested modalities. The test for the evaluation of a discrimination sensation – **FMT** – testing the surface texture (Fig. 1) showed in all subjects a zero deficit in both initial and the final examination in the **unimpaired extremity**. Nine subjects corresponded to the standard in the **paretic extremity** in the initial examination. In two subjects deterioration from the standard into the off the standard state in the final examination was observed. In two subjects a mild improvement was seen and four subjects remained off the standard.

The **RASP** showed deficit on both sides before and after therapy. The modalities evaluated by means of RASP (Fig. 2a, b) on the **unimpaired side** were, in most subjects, within the standard in the **initial examination**. Some deficit was found in the modalities: "*sharp/dull discrimination*" (4 subjects), "*surface pressure touch discrimination*" (1 subject), "*surface localization*" (4 subjects). The standard was found in two modalities in all subjects: "*two point discrimination*" and "*temperature discrimination*". On the **paretic side** in the initial examination, a certain degree

Fig. 1
The Fabric Matching Test



Legend (holds for all following graphs):

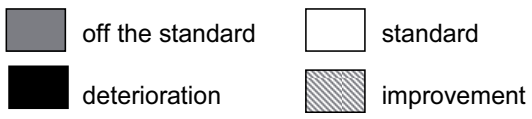
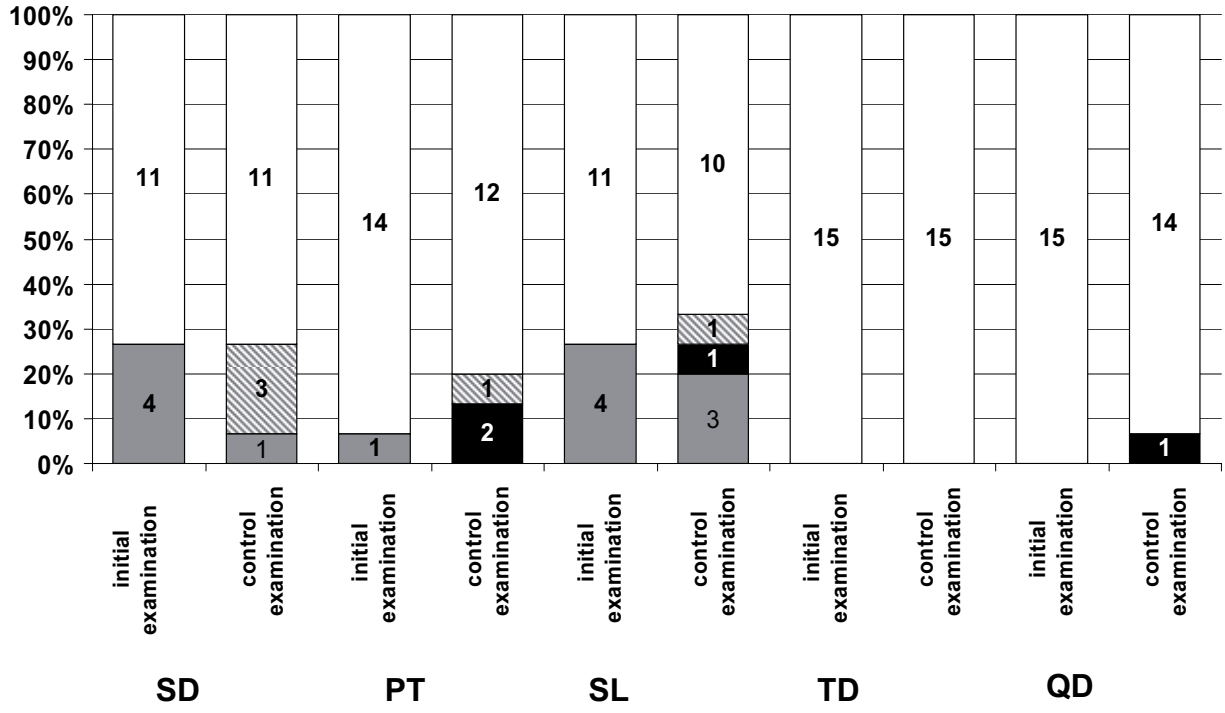


Fig. 2a
The RASP – unimpaired side



Legend:
SD – sharp/dull discrimination
PT – surface pressure touch
SL – surface localization
TD – two point discrimination
QD – temperature discrimination

Fig. 2b
The RASP – impaired side

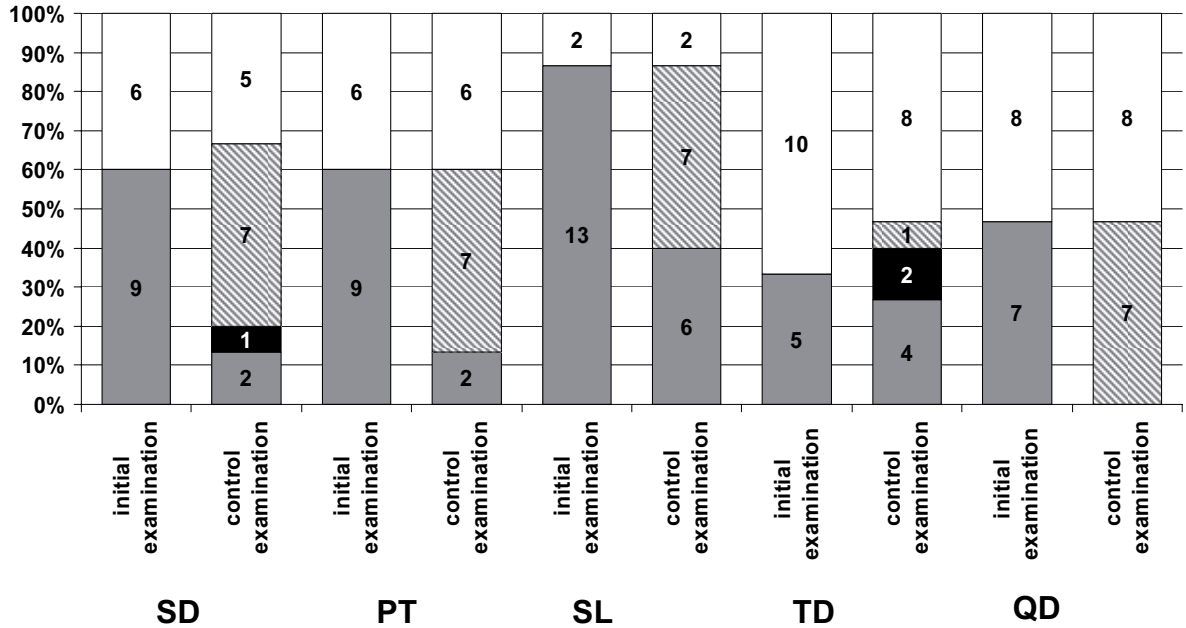


Fig. 3
The NHPT

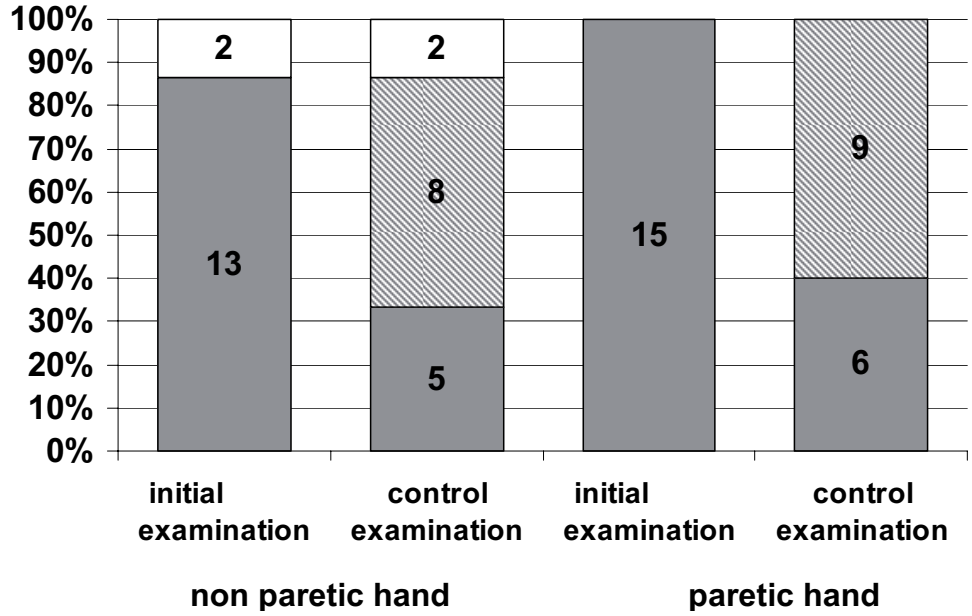


Fig. 4 a
The TMF – subtest Pyramid – unimpaired extremity

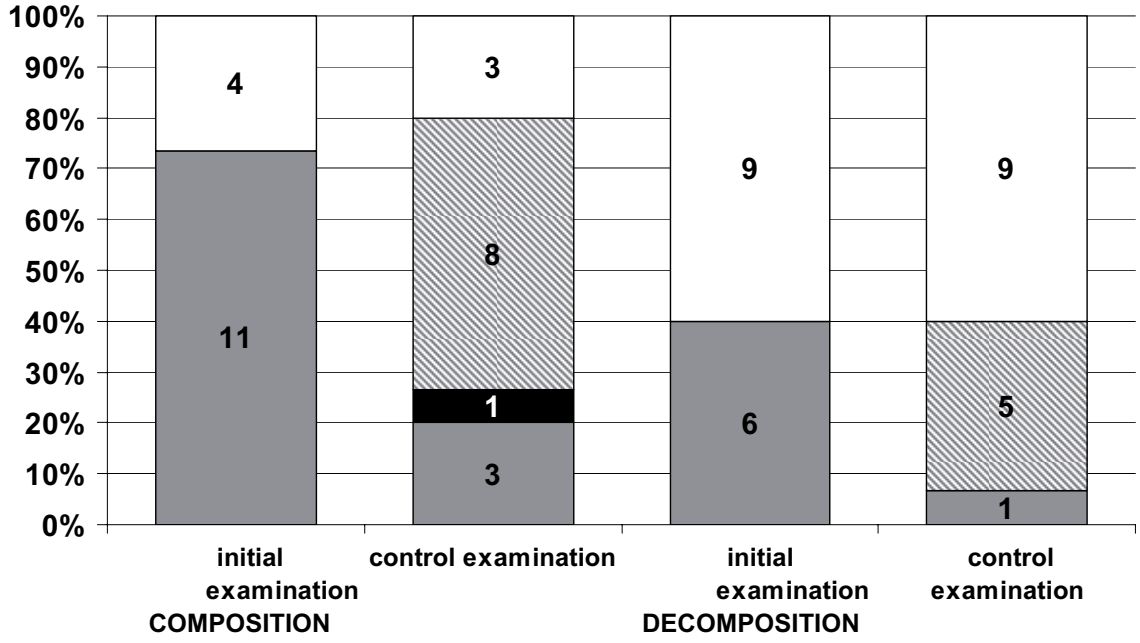


Fig. 4b
The TMF – subtest Pyramid – paretic extremity

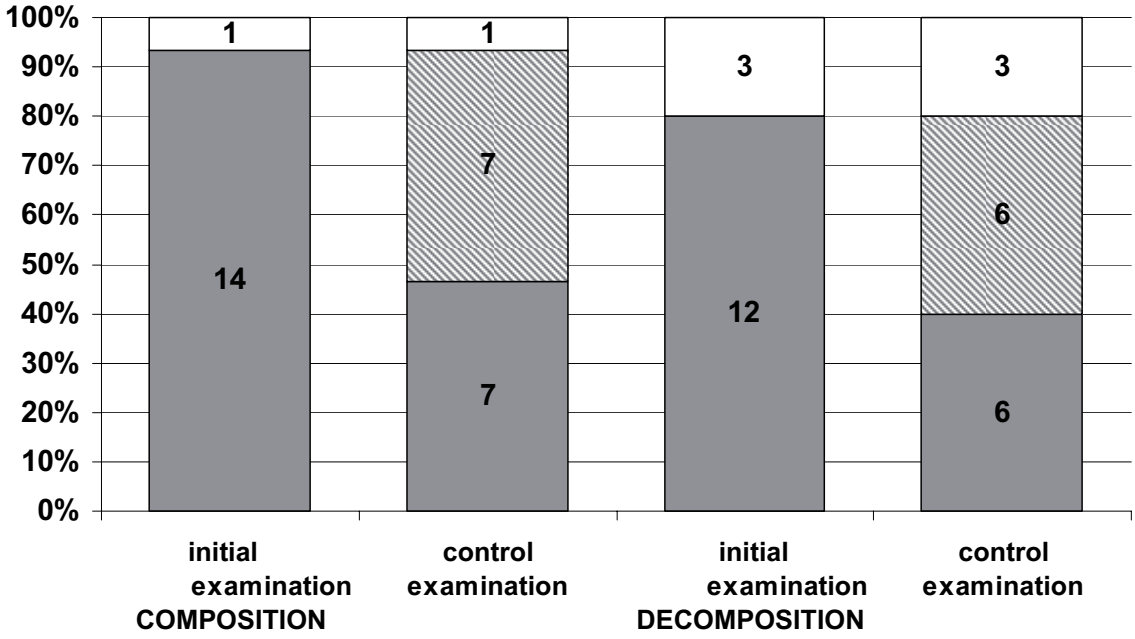


Fig. 5a
The TMF – subtests Mummy – unimpaired extremity

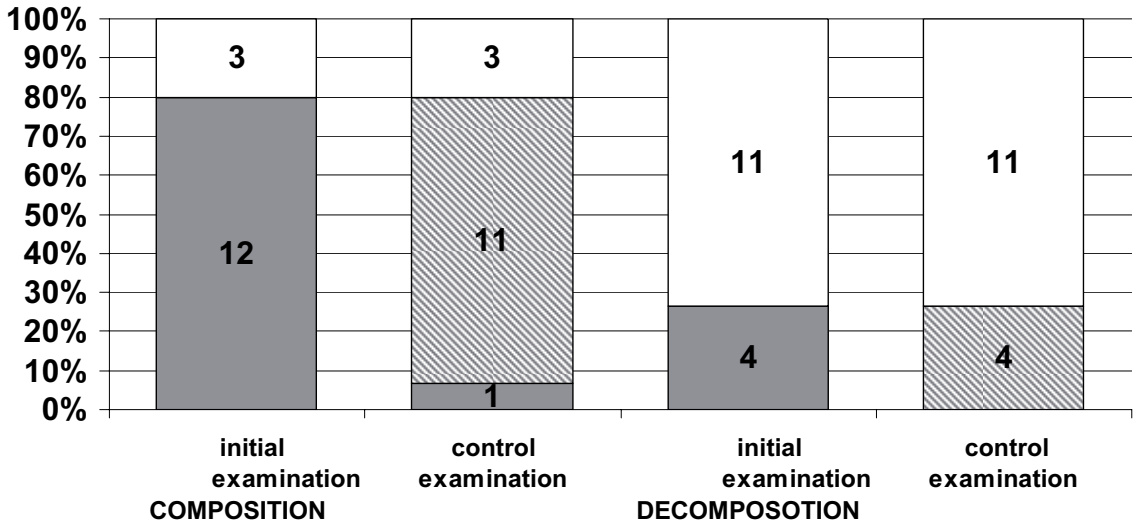


Fig. 5b
The TMF – subtests Mummy – paretic extremity

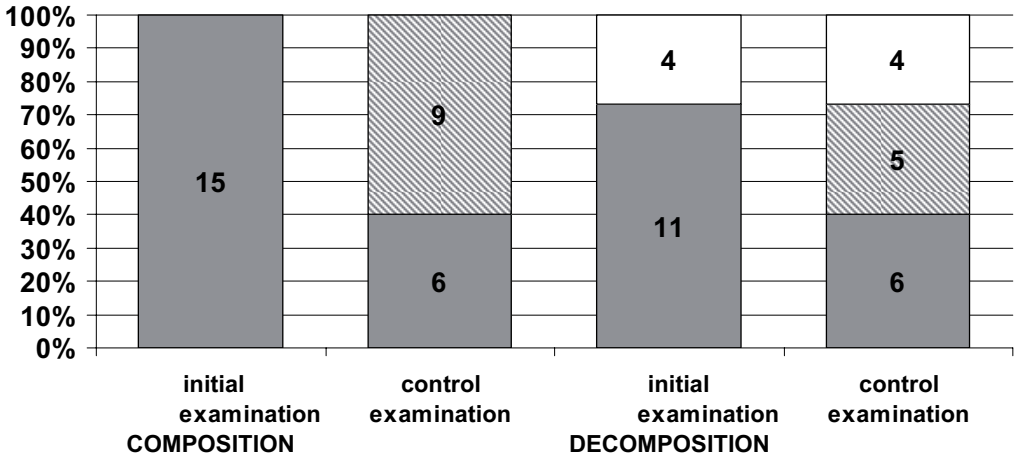


Fig. 6a
The TMF – subtests Cube – unimpaired extremity

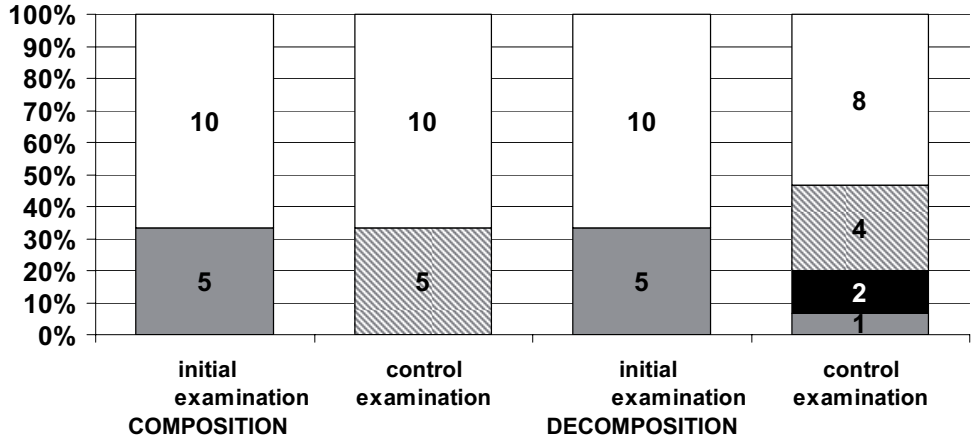


Fig. 6b
The TMF – subtests Cube – paretic extremity

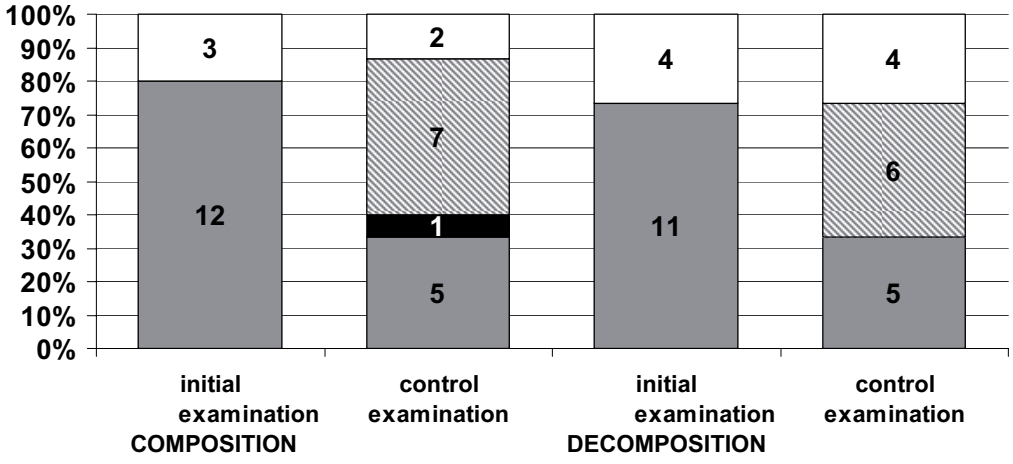
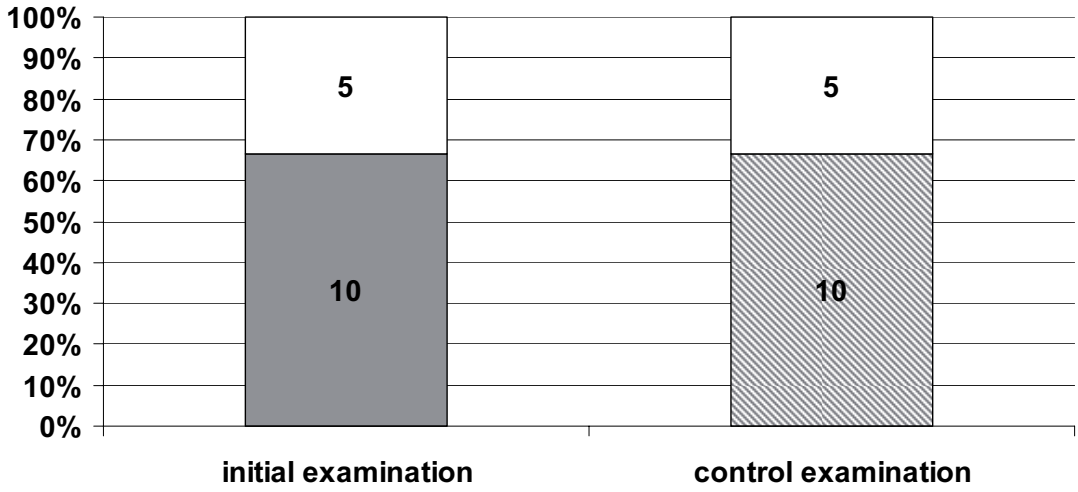


Fig. 7
The Barthel Index



of deficit in all the modalities was found. The largest number of subjects having a deficit were found in the modality "*surface localization*" (13 subjects), "*sharp/dull discrimination*" and "*surface pressure touch discrimination*" (9 subjects). The deficit observed in the smaller number of subjects was in the modality "*temperature discrimination*" (7 subjects) and "*two point discrimination*" (5 subjects).

After therapy the biggest improvement in the modality "*sharp/dull discrimination*" (3 subjects) on the **unimpaired side** was seen. In the modalities "*surface pressure touch discrimination*" (2 subjects), "*surface localization*" (1 subject) and "*temperature discrimination*" (1 subject), on the other hand, some deterioration of their state was observed.

As for the **paretic side**, most subjects (7 in each case) showed improvement in the modalities "*sharp/dull discrimination*", "*surface pressure touch discrimination*", "*surface localization*" and "*temperature discrimination*". In two modalities ("*sharp/dull discrimination*" and "*two point discrimination*") some deterioration in the results was seen.

The NHPT was performed on the unimpaired and paretic extremity (Fig. 3). As for the **unimpaired extremity**, 2 subjects were within the standard in the **initial examination**. The 13 subjects left were off the standard. Eight subjects improved their performance **after therapy** and 5 remained off the standard. In the **paretic extremity** some deficit was found in both the **initial and control examination** in all 15 subjects, but **after therapy** some improvement in 9 subjects was observed. No subject showed any deterioration of performance.

The TMF (Fig. 4a, 6b) was performed on the unimpaired and paretic extremity. In the **initial examination** of the **unimpaired extremity**, the largest number of subjects had a deficit of manipulation functions in the subtests "*Assembling the mummy*" (12 subjects) and "*Assembling the pyramid*" (11 subjects). During the **final examination** a great improvement of the deficit in both subtests was observed. In the subtest "*Assembling the mummy*" 11 subjects showed improvement and in the subtest "*Assembling the pyramid*"; 8 subjects indicated improved performance. Some deterioration was observed in the subtests "*Dismantling the cube*" (2 subjects) and "*Assembling the pyramid*" (1 subject). Three subjects were found off the standard in the subtest "*Assembling the pyramid*" and 1 subject in the subtests "*Dismantling the pyramid*", "*Assembling the mummy*" and "*Dismantling the cube*", respectively.

In the **initial examination** of the **paretic extremity**, the largest number of subjects with the deficit of manipulation functions in the subtests "*Assembling the mummy*" (15 subjects), "*Assembling the pyramid*" (14 subjects), "*Dismantling the pyramid*" and "*Assembling the cube*" (12 subjects) was found.

In the **final examination** a certain deficit improvement in all the subtests was seen at least in 50% subjects. In the subtest "*Assembling the mummy*" 9 subjects indicated improvement, 7 subjects in the subtests "*Assembling the cube*" and "*Assembling the pyramid*", 6 subjects in the subtests "*Dismantling the cube*" and "*Dismantling the pyramid*" and in the subtest "*Dismantling the mummy*", 5 subjects improved their deficit. Only in one subject deterioration was seen in the subtest "*Assembling the cube*".

The results of the **ADL test** (Barthel Index) are showed in Fig. 7. Ten subjects were observed to be off the standard in the **initial examination**. In the **final examination** a certain deficit improvement in all these subjects was seen. Nobody got worse.

DISCUSSION

Using the above described tests, we studied whether there is a deficit of somatosensory and motor functions and if it changes during the post-acute phase after stroke in the localization of the hand. No deficit in any subject was found on the so called **"unimpaired" side** in the **initial examination** only in the modalities "*surface pressure touch discrimination*", "*two point discrimination*" and "*temperature discrimination*" (although the state of one subject got worse during the final examination of temperature discrimination). In other studied items a number of subjects with a deficit always were seen in the observed group. Four subjects in the group manifested a conforming deficit that was evaluated as "off the standard" in the modalities "*sharp/dull discrimination*" and "*surface localization*". In one subject the deficit showed in the modality "*surface pressure touch discrimination*".

In the tests of fine motor function, a high degree of deficit (NHPT: 13 subjects; TMF: mostly in the subtest "*Assembling the mummy*" – 12 subjects, in the subtest "*Assembling the pyramid*" – 11 subjects) was found in the "unimpaired extremity".

During the **final examination** the biggest improvement was observed in the modality "*sharp/dull discrimination*" (3 subjects), in the test of fine motor function NHPT (8 subjects) and in subtests of TMF "*Assembling the pyramid*" (8 subjects) and "*Assembling the mummy*" (11 subjects). However, a certain deterioration of the performance in the modalities such as "*surface pressure touch discrimination*" (2 subjects), "*surface localization*" (1 subject), "*temperature discrimination*" (1 subject), in the subtest "*Assembling the pyramid*" (1 subject) and "*Dismantling the cube*" (2 subjects) occurred. It may be concluded that the condition of the unimpaired extremity, except for the above mentioned deterioration, was in course improvement. Despite this, 5 subjects (one third) remained without changes in the category "out of standard" in the test NHPT. A mild improvement in their performance was seen in all the subtests in TMF.

In the **paretic extremity** during the **initial examination** a deficit occurred much more frequently in each tested modality when compared with the unimpaired side. From the view point of somatosensoric functions, the largest number of subjects with a deficit was observed in the modalities: "*surface localization*" (13 subjects), "*sharp/dull discrimination*" (9 subjects), "*surface pressure touch discrimination*" (9 subjects) and in the tests of fine motorics (NHPT – 13 subjects; TMF – subtest "*Assembling the pyramid*" – 11 subjects and subtest "*Assembling the mummy*" – 12 subjects).

According to the results of the **final examination**, the deterioration of discrimination sensation (discrimination of the surface texture) in the **paretic extremity** was observed after therapy and in 40% of subjects the deficit continued. In conformity with the results of the RASP test, a conspicuous improvement was found in the modalities "*sharp/dull discrimination*", "*surface localization*" and "*surface pressure touch discrimination*". Winward et al. (2007), who also used the RASP test in their study to evaluate somatosensory deficit, suggest that no patient within the studied group achieved full recovery on all somatosensory subtests four weeks after they had a stroke, however, the general trend was one of gradual incremental recovery in most modalities. As the most important finding, they mention an evident oscillation in the performance of somatosensory functions in an individual patient and between patients as opposed to the relatively stable finding in the motor functions and activities of daily living.

According to the NHPT a deficit of the fine motor function in the paretic extremity was found in all the subjects, but 9 out of them showed a mild improvement of their performance. The results correspond to those found by Blennerhassett et al. (2006) who suggest that stroke performance on the pinch grip lift and hold task is likely to differ from typical grip force patterns employed by healthy adults. Delayed grip formulation and variable grip force application are key characteristics of grip dysfunction after stroke.

In conformity with the results of the TMF the deficit was seen in the paretic extremity in the initial examination in all subtests in more than 70% of the subjects and, after therapy, in the final examination the deficit was found in more than 60% of the cases. Contrary to the NHPT, which tests only one type of a precise (pinch) grip, the TMF tests a broader scale of grips so that in each subtest a mild improvement in several subjects may be observed. The largest number of improvements was seen in the subtest "*Assembling the mummy*" (9 subjects). In the subtest "*Assembling the cube*", a certain deterioration was found in one person. In the paretic extremity more than 30% subjects were off the standard in all subtests.

From these study results it is obvious that the sensory and motor deficit in one sided lesions in the post-acute phase after stroke may be seen even in the upper extremity on the unimpaired side. In this case fine motor function is impaired more than somatosensory functions. After 4 week rehabilitation some subtests showed even a certain deterioration.

Interestingly, it may be considered that the unimpaired "two point discrimination" and "surface discrimination" in the unimpaired extremity was found when compared with the modalities "sharp/dull stimuli discrimination", "surface pression touch", "localization of touch" and "temperature stimuli discrimination". The most impaired modalities: "sharp/dull stimuli discrimination", "surface pression touch", and "localization of

touch" are identical in both the paretic and the unimpaired extremity.

The greatest decrease in deficit after therapy was shown in the Barthel Index aimed at current daily activities. It is obvious that current therapy focuses particularly on these activities. Moreover, it is here allowed to compensate for the function using a substitute mechanism. The clear improvement of ADL (evaluated by Barthel Index) corresponds to our results. It is disputable whether the therapy aimed at the above mentioned modalities will bring better results. This hypothesis should be verified with future subjects.

CONCLUSIONS

In the post-acute phase after stroke in unilateral lesions, the impairment of sensation and motor functions occur even on the upper limb of the unimpaired side. The fine motor function is thus affected more than somatosensory functions. The extent of the impairment of somatosensory functions does not correspond to the extent of the impairment of motor functions in the upper limbs.

In tests of fine motor function some deficit was seen even in the unimpaired extremity. The tasks demanding precise grip showed the highest deficit.

Motor and functional recovery demonstrated continuous improvement over time; somatosensory recovery showed marked variation in subtests, within, between and among patients.

The most conspicuous changes during the evaluation of subjects were registered in ADL as assessed by the Barthel Index – the return of functions towards the standard was observed in one third of the subjects.

It is necessary to administer more tests to answer the question whether the therapy specifically targeted to influence the degree of the given modalities could be improved.

If the results of the second stage of the research project that has been carried out at present show the therapeutic effect, we suggest including the testing and the targeted therapy as a standard part of rehabilitation in patients after stroke.

ACKNOWLEDGMENT

The study has been supported by the research grant from the Ministry of Education, Youth and Sports of the Czech Republic (No. MSM 6198959221) "Physical Activity and Inactivity of the Inhabitants of the Czech Republic in the Context of Behavioral Changes".

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HODNOCENÍ MÍRY REKONVALESCENCE SENZOMOTORICKÝCH FUNKCÍ RUKY VE SKUPINĚ REHABILITOVANÝCH PACIENTŮ PO MRTVICI V POSTAKUTNÍM STÁDIU

(Souhrn anglického textu)

VÝCHODISKA: Deficit senzomotorických funkcí ruky u pacientů po CMP je velmi častý. Přesto je algoritmus jejich obnovy relativně málo známý. Není jasné, zda rozsah či typ poruchy somatosenzorických funkcí koreluje s horší obnovou motoriky.

CÍLE: Tato studie byla zaměřena na sledování senzomotorických funkcí ruky u skupiny pacientů v postakutním stádiu po ischemické CMP, lokalizované v povodí arteria cerebri media. Cílem bylo zjistit míru úpravy somatosenzorických a motorických funkcí ruky u sledované skupiny. Jedná se o první etapu výzkumu, na kterou bude navazovat sledování experimentální skupiny s terapií cílenou na somatosenzorické funkce.

METODIKA: Sledovaná skupina pacientů byla léčena na oddělení kliniky lůžkové rehabilitace a prošla standardní terapií po dobu 3–4 týdnů. K hodnocení senzomotorických funkcí ruky byly použity 2 testy čití: FMT – Test srovnávání textury látek a RASP – Rivermeadské hodnocení somatosenzorických funkcí a 2 testy motoriky: NHPT – Devítikolíkový test a TMF – Test manipulačních funkcí ruky pomocí stavebnice Ministav. Testy byly provedeny na začátku a na konci terapie.

VÝSLEDKY: U sledované skupiny pacientů jsme zjistili poruchy somatosenzorických funkcí a motoriky i na horní končetině nepostižené strany. Jemná motorika je přitom postižena více než somatosenzorické funkce. Největší deficit u motorických funkcí vykazovaly úkoly vyžadující precizní úchop. Nejvýraznější změny při hodnocení pacientů byly registrovány v ADL, hodnocených indexem Barthelové – k úpravě funkcí do normy došlo u 1/3 pacientů.

ZÁVĚRY: Po aplikaci standardní terapie došlo u sledované skupiny pacientů ke zlepšování senzomotorických funkcí ruky, ale výsledky nejsou konsistentní, někteří pacienti se zhoršili a někdy došlo jen k mírné úpravě. Je nutno otestovat, jaké budou výsledky experimentální skupiny pacientů, s terapií specificky cílenou na ovlivnění somatosenzorických funkcí.

Klíčová slova: cévní mozková příhoda, hemiparetická ruka, somatosenzorické funkce, jemná motorika, testy ruky.

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