

## The evaluation of the rehabilitation effects on cognitive dysfunction and changes in psychomotor reactions in stroke patients

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**Key words:** stroke; rehabilitation; occupational therapy; cognitive dysfunctions; reaction time.

**Summary.** Stroke patients often experience cognitive dysfunctions. One of the parameters assessing cognitive function is the reaction time as it reflects the speed of information processing.

The aim of the study was to assess cognitive and psychomotor dysfunctions and the effectiveness of rehabilitation in stroke patients. The subjects of the study were 30 stroke patients who underwent rehabilitation at the Department of Neurorehabilitation. The mean age of patients was  $65.33 \pm 13.2$  years. During the study, the patients' cognitive functions, the handgrip strength, reaction time, and frequency of movements were assessed.

There was a substantial improvement in patients' cognitive function after rehabilitation. Assessing the results obtained by Mini Mental State Examination, the change was  $6.4 \pm 2.3$  points, and assessing by Neurobehavioral Cognitive Status Examination (Cognistat), the change was  $13.3 \pm 10$  points ( $P < 0.05$ ). Before the early stage of rehabilitation, Cognistat results showed that the majority of the patients experienced memory loss, diminished constructive abilities, and disorientation. After occupational therapy, there was a statistically significant improvement in all cognitive function domains. At the end of the inpatient rehabilitation period, there was a significant change in patients' reaction time and movement frequency.

At the end of early rehabilitation stage, the estimated reaction time in patients with stroke was compared with reaction time in healthy elderly people of the same age. There was no significant difference between these groups; consequently, we concluded that after rehabilitation, improvement of function was achieved.

The results of this study showed that at the beginning of early rehabilitation period and after rehabilitation applied, there was a significant moderate correlation between mental state and reaction time in stroke patients.

### Introduction

Close to one million people suffer from stroke in the European Union yearly (25% of men and 20% of women older than 85 years). It is expected that in the next two decades, the rate of stroke will increase due to the rapid growth of elderly population (1).

Stroke is the second leading cause of death worldwide after heart and vascular diseases and is one of the main causes of disability in older patients. Stroke patients usually require hospitalization followed by family and community or nursing home care (2).

Many scientists emphasize early inpatient rehabilitation of patients suffering from cerebral stroke, as it has a high impact on further process of disease, determines better quality of life (3).

Stroke patients often experience cognitive dysfunctions. Different sources indicate that cognitive dysfunction and dementia are present in 16.8–31.8% of stroke patients (4). Such disorder may range from slight memory impairment or temporal orientation im-

pairment to irreversible dementia (5).

Meijer and coauthors reported that one of factors determining poor outcome after stroke is cognitive disorder (6). Based on recent findings, cognitive dysfunctions affecting patients' behavior and daily life might limit their functional rehabilitation during hospitalization, influence the length of hospital stay and quality of life as well as independence during the later stages of the disease and are key factors in predicting the outcome of the stroke (5).

Cognitive dysfunction is assessed by an occupational therapist during initial evaluation and later interaction with the patient. Important indicators are patient's adaptation capabilities while planning, thinking, and solving problems and initiating activities. In accomplishing daily tasks, these capabilities are as important as the patient's physical condition (7).

One of the parameters assessing cognitive function is the reaction time as it reflects the speed of information processing (8). It is indicated in the literature

that three methods could be used to assess the level of the patient's cognitive functioning: 1) cognitive recognizing and understanding tests; 2) assessment of general or fractional reaction time; 3) electrophysiological or neurophysiologic studies (8).

Frequent and more complex coordination activities promote the function of the central nervous system (focusing, logical thinking, decision making, etc.) Therefore, by measuring the movement frequency, we are able to evaluate a number of patient's functional capabilities and first and foremost the agility of the central nervous system (9).

A widely known tapping test is used to measure the frequency of minimal movements, when minimal muscle contraction and extension are measured within a certain time frame (9).

Platz et al. (10) claim that cognitive process has a very limited influence on the ability to regain movements after stroke. Whereas study results by Cirstea et al. (11) indicate that various levels of cognitive ability are needed for successful movement capabilities. The results of their study show that the improvement in patients' motor skills was directly related to better memory, thinking, reasoning, and planning/problem solving skills. It is assumed that the latter cognitive processes are involved in processing important information related to movement and effectiveness of movement recovery. Therefore, evaluation and modification of cognitive dysfunction must play an essential part in motor rehabilitation program. In their study, de Groot-Driessen et al. (12) used the tapping to investigate the change in speed of movement of unaffected hand in patients following 6 months after stroke and whether the speed of movement in unaffected hand was related to functional results of neurorehabilitation. The patients were tested upon admittance to rehabilitation, 4 weeks after admittance, at discharge, and at 3 months after discharge. The tapping test was used to assess 57 first-time unilateral stroke patients and 42 spouses (control group) with no neurological dysfunctions. The test results indicate that the speed of movement in unaffected hand improved significantly 4 weeks after discharge (mean range of 44.13–47.30,  $P=0.02$ ) and remained unchanged up to 3 months following the discharge. Hand movement speed correlated with the functional results, but was not related to the overall quality of life; the tapping test results were not significant in predicting everyday functional capabilities of patients. The test results indicate that assessing the speed of movement in unaffected hand is a useful indicator in the evaluation of rehabilitation of the stroke patients.

Up till now, no studies have been performed to

measure cognitive dysfunction in stroke patients using a reactiometer in Lithuania. In Lithuania, the reaction time is usually measured using a simple time monitor RTM-802. It is a special ruler with the markings of milliseconds. Using this method, only reaction time up to 0.295 s can be measured.

### Research subjects and methods

The subjects of the study were 30 hemorrhagic stroke and brain infarction patients who underwent treatment at the Department of Neurorehabilitation, Hospital of Kaunas University of Medicine. The study was performed in 2006–2007, and it was approved by the Hospital's Bioethical Center. The subjects were chosen in accordance with the patients' cognitive function assessment using a well-known Mini-Mental State Examination (MMSE) test.

Patients with mild and moderate cognitive dysfunctions (up to 24 points) were tested. Further, to assess cognitive function in patients, the Neurobehavioral Cognitive Status Examination (Cognistat) was also used (13). The latter is composed of 12 sub-tests enabling to evaluate five different areas of cognitive ability: speech, constructive capabilities, memory skills, counting, and comprehension.

The findings of studies indicated that MMSE was useful in observing main cognitive function capabilities of stroke patients, whereas Cognistat not only assessed the above findings but also was more sensitive in evaluating remaining cognitive abilities of the patients (14).

Cognistat enables us to measure the level of multiple cognitive dysfunctions allowing us to determine which areas are affected the most by the improvement in patient's motor skills.

The speed of patients' psychomotor reactions was measured using a reactiometer RA-1 (JSC BALTEC CNC TECHNOLOGIES, Kaunas), and the strength of handgrip was assessed using a dynamometer. The reactiometer is a device used to measure a person's reaction time to light or sound stimulation as well as to characterize the speed of the psychomotor reaction of the central nervous system of the patient. The device is used alongside the standard personal computer and a special computer program. When measuring the reaction to light, the patient sits in front of the device and presses a button whenever he/she sees a light signal. The device records the interval of time between the moment when the patient sees the light and he/she presses the button. Auditory speed reaction is measured from the moment the patient hears a sound signal to the moment he/she presses either one of the two buttons. During a tapping test, the subject sits at

the table holding “a stick,” which he/she then uses as frequently as possible to touch the board of the apparatus in a given period. The number of taps is automatically counted.

Thirty subjects were tested: 10 men and 20 women (33% and 67%). The mean age of the patients was  $65.3 \pm 13.2$  years. Thirty-six percent of patients had elementary school education; 32%, secondary school education; 19%, junior college education; and 13%, higher school education. Fifty-three percent ( $n=16$ ) of patients experienced dextrocerebral stroke dysfunction and 47% ( $n=14$ ) experienced sinistrocerebral stroke dysfunction.

Special rehabilitation programs were designed for stroke patients based on their functional abilities and applied by a rehabilitation team. The patient was encouraged to participate actively in the treatment program alongside with his/her family members. All the subjects underwent occupation therapy 5 times a week. The length of a single session was 30 minutes, and the course of rehabilitation was 48 days.

## Results

### *Assessment of cognitive functions using MMSE and Cognistat tests*

The mental condition of the subjects was tested using MMSE and Cognistat at the beginning and at the end of the rehabilitation period.

Before rehabilitation, patients' MMSE was  $20.8 \pm 3.6$  points, which indicates a mild dysfunction. After completing the rehabilitation, patients' mental condition assessed by the same test was improved yielding a score of  $27.2 \pm 2.2$  points, which was the norm. The improvement rate of cognitive functions assessed using MMSE was 6.4 points (95% PI, 5.6–7.3). The achieved results were statistically significant ( $P < 0.05$ ).

Using Cognistat in assessing mental abilities allows measuring the severity of cognitive dysfunction

in patients: mild, moderate, or severe dysfunction.

The degree of different cognitive dysfunctions and its dynamics in the course of rehabilitation are presented in Figs. 1–7.

Fig. 1 demonstrates that at the beginning of rehabilitation, 27% of patients experienced moderate orientation dysfunction. Following the treatment, the orientation dysfunction improved 100%.

Data presented in Fig. 2 show that 17% of patients experienced moderate attention disturbance, and 30% experienced mild disturbance at the beginning of the treatment. At the end of the rehabilitation period, 3% of subjects continued to experience mild attention disturbance.

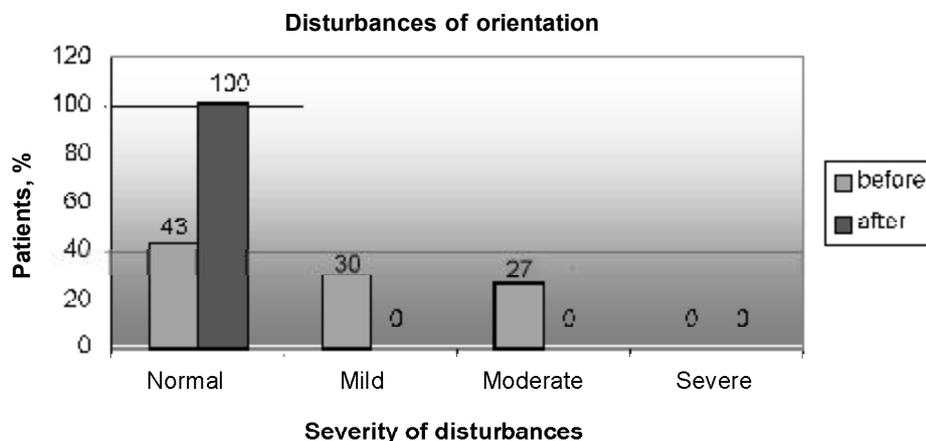
At the initial assessment, 17% of subjects experienced moderate counting disturbance. Following rehabilitation, 7% of patients continued to experience mild counting impairment (Fig. 3).

Memory loss of various degrees was present in 83% of patients at the beginning of rehabilitation. They were rated as follows: 30% with moderate dysfunction and 20% with severe memory dysfunction (Fig. 4). After applied occupational therapy, 10% of patients continued to experience moderate memory dysfunction and 30% – mild memory dysfunction, respectively.

Seventy percent of subjects experienced constructive disturbances, 3% were diagnosed with severe dysfunction, and 23% with moderate dysfunction (Fig. 5). After applied occupational therapy, 3% of patients continued to experience moderate and 10% mild constructive disturbances, respectively.

The assessment of patient's skill problems demonstrated that 13% of subjects initially experienced mild dysfunction, which was reversed in all patients following rehabilitation (Fig. 6).

Twenty-seven percent of patients were diagnosed with mild dysfunction in the area of similarity listing



**Fig. 1.** The level of orientation dysfunction of patients at the beginning and at the end of rehabilitation

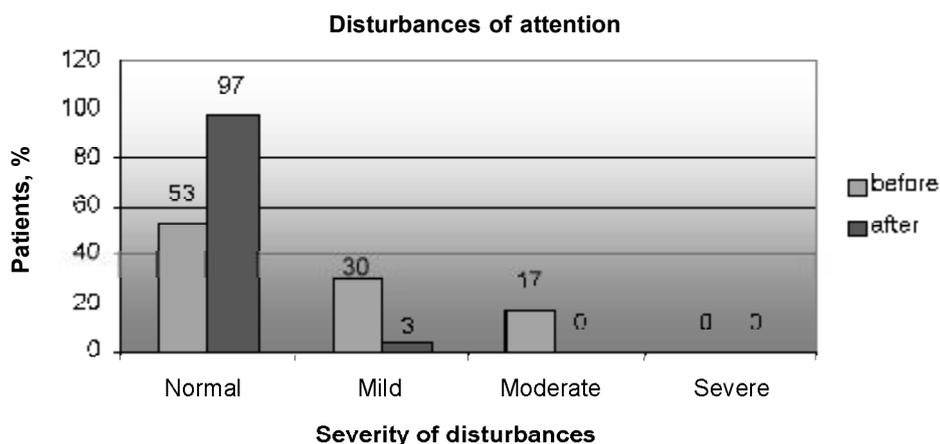


Fig. 2. The level of attention disturbance of patients at the beginning and at the end of rehabilitation

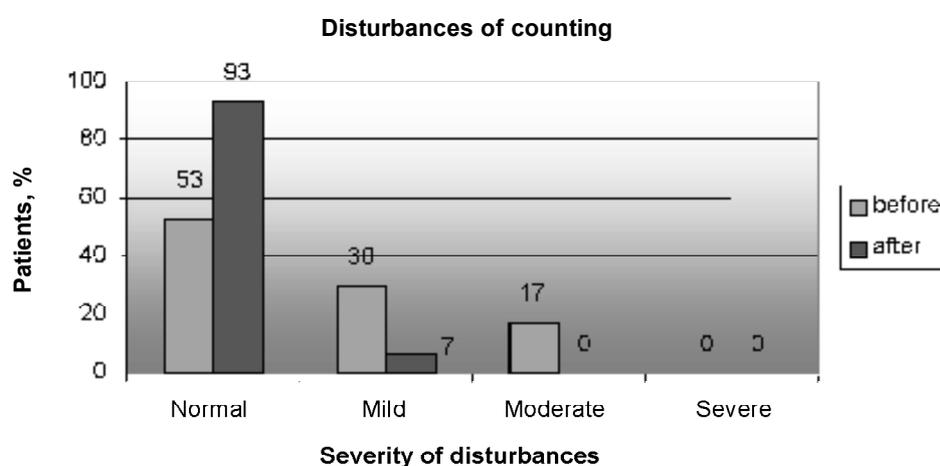


Fig. 3. The level of counting disturbance of patients at the beginning and at the end of rehabilitation

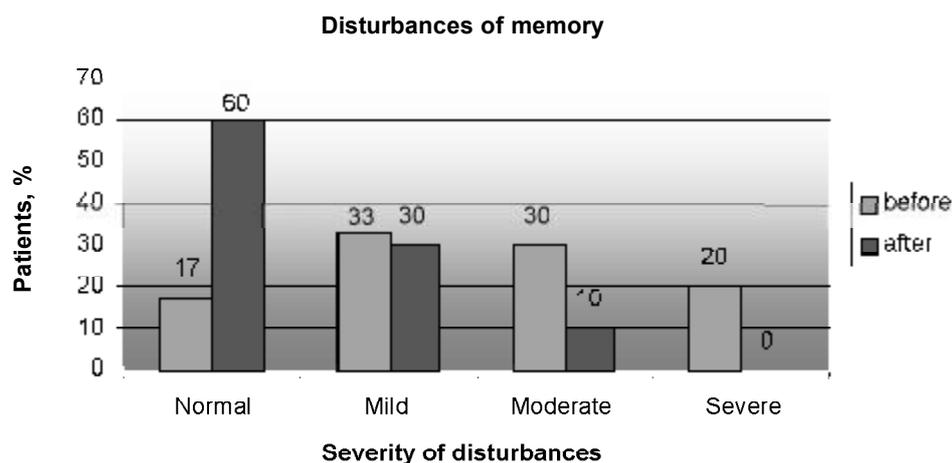


Fig. 4. The level of memory dysfunction of patients at the beginning and at the end of rehabilitation

task. The ability to name similarities in objects and categorize them demonstrates the individual's comprehension flexibility. Fig. 7 demonstrates that following occupational therapy, 3% of patients continued to experience severe, 3% moderate, and 27% mild dysfunction.

In Cognistat, at the beginning of rehabilitation, the

score of cognitive functions was  $57.7 \pm 13.7$  points. After completion of rehabilitation, the patients scored  $71 \pm 9.1$  points on average. Mean improvement rate of cognitive functions using Cognistat was 13.3 points (95% CI, 17–9.5;  $P < 0.05$ ).

The assessment of changes in cognitive dysfunc-

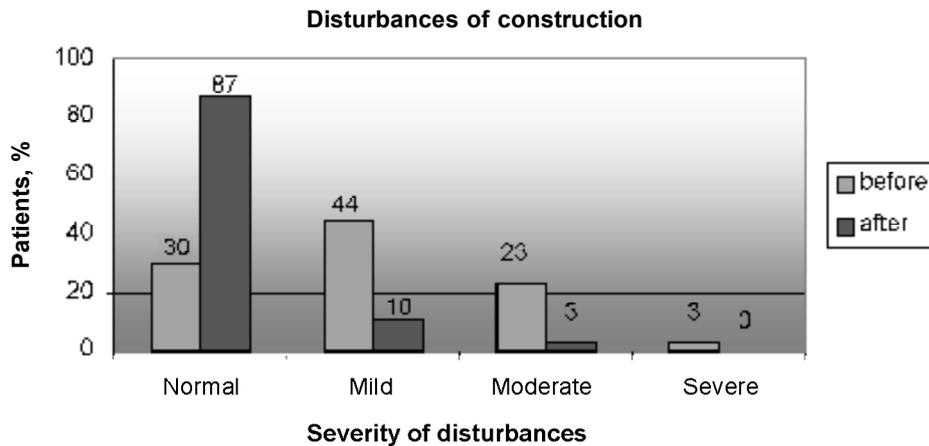


Fig. 5. The level of constructive disturbances of patients at the beginning and at the end of rehabilitation

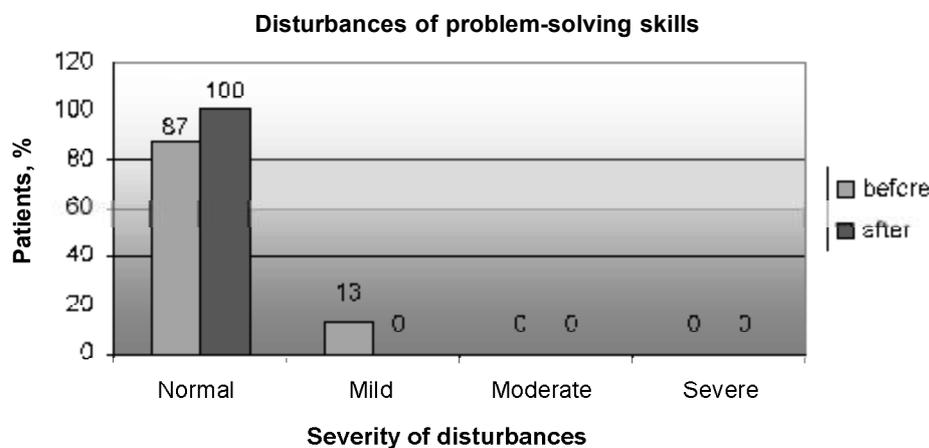


Fig. 6. The level of patient's skills problems at the beginning and the end of rehabilitation

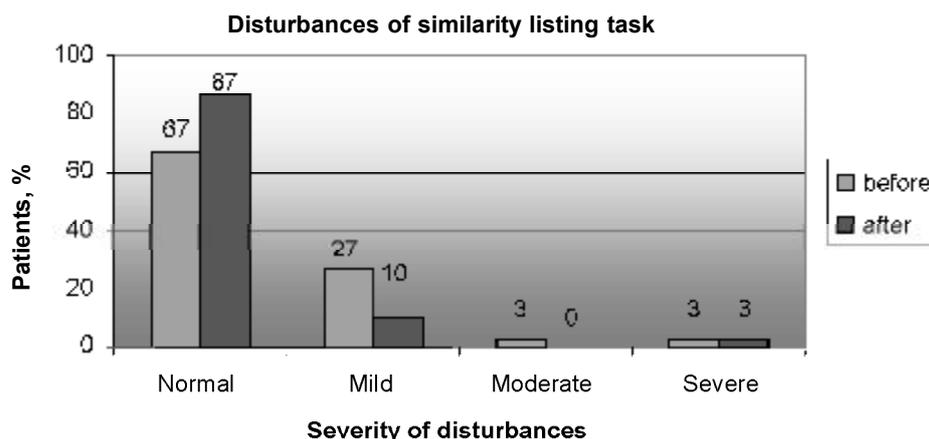


Fig. 7. The level of dysfunction in the area of similarity listing task of patients at the beginning and at the end of rehabilitation

tion using Cognistat before and following occupational therapy indicated a statistically significant difference in subject's scores.

The scores of constructive abilities, memory, and similarities were distributed normally; therefore, Student's *t* criteria were calculated. The mean score diffe-

rences reflecting the function improvement are displayed in Table 1.

The differences in scores of orientation, attention span, counting ability, and problem solving did not meet the presumption of normality; therefore, the score differences were assessed using Wilcoxon's test, and

**Table 1. The assessment of changes in cognitive dysfunctions of patients using Cognistat before and following occupational therapy**

Cognitive function	X (points)	SD	95% CI	P
Orientation	2.5	1.7	1.8–3.1	0.0005
Attention disturbance	1.6	1.2	1.1–2.0	0.0005
Constructive disturbances	1.4	1.0	1.0–1.7	0.0005
Memory dysfunction	2.4	1.9	1.7–3.1	0.0005
Counting ability	0.8	0.8	0.6–1.1	0.0005
Similarity listing task	0.9	1.0	0.5–1.3	0.0005
Problem solving	0.5	0.7	0.23–0.8	0.001

SD – standard deviation, CI – confidence interval, X – mean difference.

confidence intervals were calculated.

The results presented in Table 1 demonstrate that the greatest difference in cognitive abilities was observed in the areas of orientation and memory dysfunction (on average, 2.5 and 2.4 points).

#### ***The assessment of the dynamics of reaction time changes during the early stage of rehabilitation***

In the study, we tested reaction time of patients' unaffected hand and movement frequency. Findings by de Groot-Dreissen et al. (12) demonstrate that movement frequency of unaffected hand is a useful indicator of recovery after stroke, as cerebral vascular accident in one of brain hemispheres is very often accompanied by disturbed blood circulation in both hemispheres.

In the assessment of the dependence of the patients' handgrip strength, the reaction time, and movement frequency, Pearson's correlation coefficient was determined. In patients who had experienced the dextrocerebral vascular accident and used the unaffected hand in the test (Table 2), the correlation was determined between the right-hand strength and right-hand reaction time (RT) as well as movement frequency.

Alternatively, the correlation factor in patients with sinistrocerebral vascular accident was determined by assessing the strength of left (unaffected) handgrip,

left-hand reaction time, and tapping test results (Table 3).

The link between the patients' reaction time, movement frequency and strength of hand grip was insignificant in both early and late rehabilitation stages (assessing patients with unilateral left or right hemisphere brain injury). Based on the obtained data, we assumed that patients' reaction time and frequency of movements was not related to the handgrip strength, whereas further studies would be needed to prove the proposed hypothesis.

Calculation of Student's *t* tests by random samples revealed that a statistically significant difference in the mental status and reaction time in patients with vascular accident in different brain hemispheres was obtained only in the movement frequency assessed by tapping test ( $P < 0.009$ ) at the beginning of rehabilitation. Subjects with dextrocerebral lesion demonstrated a mean movement frequency of 197 times/min, which was significantly different from the results in patients with the sinistrocerebral vascular injury (mean movement frequency of 154 times/min). Nevertheless, a statistically significant difference was determined only before rehabilitation. The same assessment at the end of rehabilitation did not show any significant difference (Table 4).

**Table 2. In patients who had experienced the dextrocerebral vascular accident, the correlation between the right-hand strength and right-hand reaction time and movement frequency at the beginning and at the end of rehabilitation**

Criterion	The right-hand strength at the beginning of rehabilitation		The right-hand strength at the end of rehabilitation	
	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>
Reaction time (right hand)	–0.38	0.1	–0.34	0.2
Tapping test (right hand)	0.24	0.4	0.3	0.3

$P < 0.05$  ( $n = 16$ ).

*r* – Pearson's correlation coefficient; *P* – significance level.

**Table 3. The correlation between the left-hand strength and left-hand reaction time and movement frequency at the beginning and at the end of rehabilitation in patients who had experienced sinistrocerebral vascular accident**

Criterion	The left-hand strength at the beginning of rehabilitation		The right-hand strength at the end of rehabilitation	
	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>
Reaction time (left hand)	-0.26	0.4	-0.29	0.3
Tapping test (left hand)	0.28	0.3	0.3	0.3

$P < 0.05$  (n=14).

*r* – Pearson's correlation coefficient; *P* – significance level.

**Table 4. The mean difference of the mental status, reaction time, and movement frequency in patients with vascular accident in different brain hemispheres**

Mental status Reaction time Movement frequency	At the beginning of rehabilitation			At the end of rehabilitation		
	X	±SD	<i>P</i>	X	±SD	<i>P</i>
MMSE	2.3	1.3	0.1	0.5	3.4	0.6
Cognistat	3.8	4.9	0.5	0.9	11.8	0.8
Reaction time (left hand)	253.4	213.0	0.3	23.1	138.3	0.6
Reaction time (right hand)	192.7	175.1	0.3	24.8	350.9	0.8
Tapping test	43.5	13.8	0.009	7.1	44.8	0.6

SD – standard deviation, X – mean difference.

Mean reaction time assessed in men and women before rehabilitation is presented in Table 5. It shows a slightly shorter reaction time in men comparing with women ( $P > 0.05$ ). At the same time, movement frequency measured by tapping test was greater in women than men, but the difference was not statistically significant.

Findings in Table 6 demonstrate that patients' reaction time and movement frequency difference in all investigated groups of stroke patients at the end of treatment was statistically significant.

At the beginning of rehabilitation of stroke patients, we established a moderate positive correlation ( $r = 0.335$  and  $r = 0.495$ ) between subjects' mental state,

and reaction time and their level of education. Only the results obtained using Cognistat were statistically significant. Reaction time and movement frequency were not related to the subjects' level of education.

At the end of rehabilitation, a direct moderate correlation was also established between patients' education and their mental state using both MMSE and Cognistat tests ( $P < 0.05$ ). The correlation between patients' reaction time and education was very weak and statistically insignificant.

In assessing patients' reaction time progress, we relied on previously published findings. However, there is not enough experimental data obtained in Lithuania concerning individual's reaction time in stroke

**Table 5. Reaction time and movement frequency in men and women before rehabilitation**

Reaction time Movement frequency	Women (n=20)		Men (n=10)		X
	Mean	±SD	Mean	±SD	
Reaction time (left hand), ms	948.3	686.1	920.8	732.6	27.4
Reaction time (right hand), ms	699.9	567.3	348.8	567.8	351.1
Tapping test	188.7	28.5	165.4	52.7	23.3

$P > 0.05$ .

SD – standard deviation, X – mean difference.

**Table 6. Reaction time and movement frequency difference in all investigated group of stroke patients at the end of rehabilitation**

Reaction time, movement frequency	X	±SD	P
Reaction time (left hand)	581.3	561.3	<0.05
Reaction time (right hand)	265.1	550.7	<0.05
Tapping test	26.9	29.9	<0.05

SD – standard deviation, X – mean difference.

patients. In 2005, Gaigalienė et al. studied physical capabilities of elderly population in Vilnius (15). We aimed to compare the reaction time in elderly stroke patients after rehabilitation (age mean, 65.3 years) and revealed that reaction time became similar to that of healthy elderly individuals. Our findings show that the mean reaction time in healthy individuals does not differ from stroke patients' reaction time following rehabilitation (hypothesis  $H_0: m=m_0$ ;  $H_1: m \neq m_0$ ). We also calculated Student's criteria and confidence intervals. The obtained results show that there is no statistically significant difference between reaction times in healthy individuals and in our stroke patients; therefore,  $H_0$  hypothesis remains relevant.

Data of reaction time changes in subjects are presented in Table 7.

The results demonstrate that the mean right-hand reaction time was shorter than left-hand reaction time before and after rehabilitation. The greatest change in right-hand reaction times was observed among individuals aged 70–74 and 75–79 years. The same applies to the left-hand reaction times where the greatest change was observed in older subjects (70–74 years and 80 years and older).

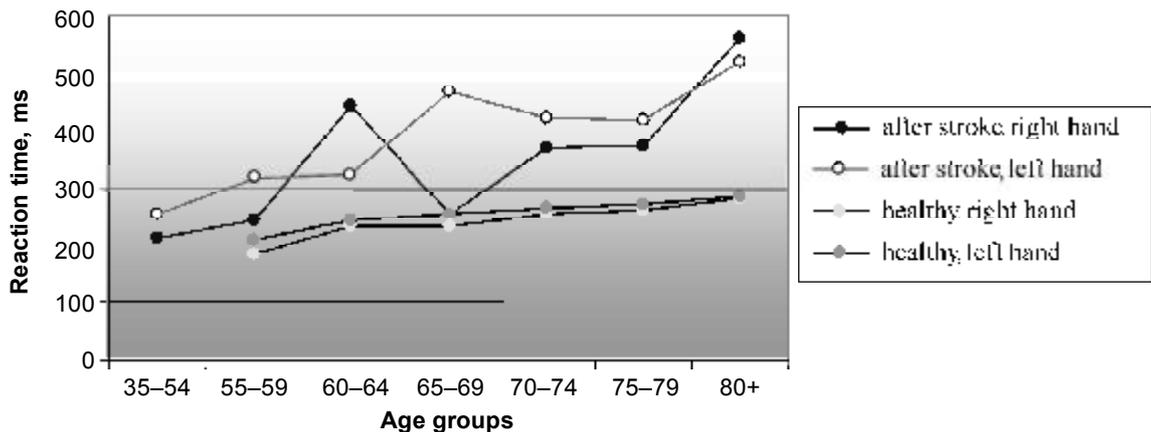
Fig. 8 shows reaction times of healthy individuals and stroke patients after rehabilitation within different age groups. The obtained results prove that reaction time increases with age in both healthy individuals and stroke patients. Right-hand reaction time appears to be shorter than left-hand reaction time, but the test results are more prominent among healthy individuals due to the bigger sample.

### Discussion

Reaction time is one of three cognitive function assessment tools reflecting the speed of information processing (8). Measuring the speed of psychomotor reaction allows assessment of impulse transmission time from the receptor to the brain sensor zone, impulse transmission and reception time to motor zone, impulse transmission time to the muscle from the motor zone, and initial muscle contraction time. Information processing in the brain takes the longest, and therefore, the latter function is exercised the most, and the change in psychomotor reaction time, in part, is affected by its instability (9). Reaction time depends on the focused attention, i.e. the readiness to react to a stimulus. It is widely accepted that focused attention

**Table 7. Reaction time of healthy individuals and stroke patients at the beginning and at the end of rehabilitation within different age groups**

Age, years	Healthy individuals			Stroke patients				
				At the beginning of rehabilitation			At the end of rehabilitation	
	Number of patients	Mean reaction time, ms		Number of patients	Mean reaction time, ms		Mean reaction time, ms	
		right hand	left hand		right hand	left hand	right hand	left hand
35–54	–	–	–	5	392.8	520.9	213.2	254.1
55–59	42	186.6	207.6	5	779.1	798.7	243.3	317.4
60–64	39	233.9	243.7	5	557.8	857.8	442.9	323.4
65–69	41	234.8	255.8	1	765.3	1380	253.3	467
70–74	36	253.7	266.1	6	1052.2	1358.2	369.2	421.8
75–79	44	260.1	271.8	4	993.1	1080.4	374.7	417.6
80>	21	280.9	286.1	4	1088.8	1389.5	560.2	518.2



**Fig. 8. Reaction times of healthy individuals and stroke patients after rehabilitation in different age groups**

is paramount in determining reaction speed and also plays a role in decision-making and in initiating the movement program. Moreover, the importance of the focused attention is directly related to the complexity of the stimulus. Based on the theory of psychophysiological movement control, control of person's movements is directly related to human physiology, i.e. efficiency has much greater dependence on psychological factors (the person's mood, interests, goals, purpose of movement, and understanding of the goals) than on physiological factors (16).

In assessing patients' reaction time progress, we relied on previously published scientific data. There are not enough experimental data in Lithuania on individual's reaction time. Moreover, based on our knowledge, reaction time in stroke patients has never been tested in Lithuania. In 2005, Gaigalienė et al. studied reaction time in healthy elderly individuals (15).

At the end of the early rehabilitation period, both MMSE and Cognistat tests used determined a positive and statistically significant change in patients' cognitive functions.

In assessment of different domains of cognitive dysfunctions, Cognistat determined that the majority of patients experienced loss of memory, constructive disturbances, and impaired orientation. At the end of rehabilitation, the greatest functional changes in cognitive functions were assessed in the domains of orientation and memory loss.

Based on the existing scientific data, we assessed the reaction time and movement frequency of the unaffected hand in stroke patients. Prigatano et al. (17) studied the hypothesis whether the movement frequency of both hands was lower in patients with a unilateral stroke and whether the movement frequency and strength of handgrip had any effect on the length of rehabilitation during the first weeks following the

stroke. After studying 51 patients, they concluded that movement frequency and the strength of handgrip in both hands of the patients were diminished, and the hand opposite to the side of the stroke was affected more. The frequency of movement in the unaffected hand was indicative of the projected results of rehabilitation, whereas the strength of the handgrip was not relevant to the final result. The frequency of movements of the impaired hand and the strength of grip in both hands were not related to the outcome of rehabilitation. The authors concluded that dysfunction of blood circulation in both hemispheres may occur as a consequence of impaired microcirculation in either one hemisphere. The frequency of movement of the hand of the stroke side could be indicative of the functional integrity of the so-called "unaffected" brain hemisphere.

We determined no reliable and statistically significant correlation between patients' reaction time and the strength of the handgrip during any stage of rehabilitation and no correlation between unaffected hand reaction time, movement frequency and handgrip strength (in stroke patients with dextrocerebral/sinistrocerebral vascular accident). After assessment of mental condition and reaction time in patients with the opposite-side cerebrovascular accident, we determined that a statistically significant score difference was present in the movement frequency only recorded by the tapping test at the beginning of rehabilitation. Patients with the dextrocerebral vascular accident had a higher mean movement frequency (197 times/min) than the patients with sinistrocerebral vascular accident (154 times/min). The difference in scores is statistically significant, but it was observed only at the beginning of rehabilitation. The results of the same test at the end of rehabilitation period were statistically insignificant.

After comparing reaction time in men and in women, we determined that men's reaction time was slightly shorter. Our results conform to previous scientific findings (18, 19); nevertheless, the mean score differences in our research were statistically insignificant.

At the end of early rehabilitation period, we established a positive and statistically significant change in patients' reaction time. Mean left-hand and right hand RTs were 581.3 ms and 265.1 ms, respectively, whereas mean auditory reaction time was 369 ms ( $P < 0.05$ ).

We based our assessment of patients' reaction time improvement following rehabilitation on the findings by Gaigalienė et al. (15). The mean reaction time of stroke patients' following rehabilitation did not differ from that of the healthy individuals; therefore, we concluded that rehabilitation helped to restore function. A moderate correlation was determined between cognitive functions and auditory reaction time.

By the assertion of Cirstea et al. (11), the improvement in patients' motor skills and reaction time is mostly related to patients' memory skills, comprehension flexibility, and problem solving skills. We used two tests (MMSE and Cognistat) to study the correlation between patients' mental condition and reaction time at the beginning and at the end of rehabilitation period. A statistically significant negative correlation was determined in results obtained using MMSE. The only statistically significant negative correlation using Cognistat was observed between left-hand reaction time and overall mental condition of the patients at the beginning and at the end of rehabilitation. Auditory reaction time results before and following the treatment showed a moderate statistically significant correlation assessed using both cognitive function assessment tests.

We also assessed the correlation between subjects' mental condition, reaction time and their level of education. Results obtained by using Cognistat at the be-

ginning of rehabilitation showed a moderate positive correlation between mental condition and education level. Reaction time and movement frequency were not related to the subjects' level of education. At the end of rehabilitation, a direct moderate correlation was also established using both tests between patients' education and their mental condition. The correlation between patients' reaction time and education was statistically insignificant. However, the findings of Gaigalienė et al. (15) have shown that the reaction time in elderly subjects with elementary or incomplete secondary education is longer than in subjects with higher education. The score difference was the greatest in subjects aged more than 65 years.

### Conclusions

1. After rehabilitation, a statistically significant improvement in cognitive abilities of stroke patients was observed. Assessment using MMSE indicated a difference of  $6.4 \pm 2.3$  points and a  $13.3 \pm 10$ -point difference using Cognistat ( $P < 0.05$ ).

2. Based on the results obtained by Cognistat in the early stages of rehabilitation, a statistically significant improvement was achieved in all cognitive function domains of the patients.

3. At the end of rehabilitation, a statistically significant change in patients' reaction time and movement frequency was documented ( $P < 0.05$ ).

4. At the end of early rehabilitation stage, the estimated reaction time in patients with stroke was compared with reaction time in healthy elderly people of the same age. There was no significant difference between these groups; consequently, we concluded that after rehabilitation, improvement in function was achieved.

5. The results of this study showed that after applied rehabilitation, there was a significant moderate correlation between the mental state and reaction time in stroke patients.

## Persirgusiųjų galvos smegenų insultu pažinimo funkcijų ir psichomotorinių reakcijų reabilitacijos veiksmingumo įvertinimas

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**Raktažodžiai:** insultas, reabilitacija, ergoterapija, pažinimo sutrikimai, psichomotorinės reakcijos laikas.

**Santrauka.** Ligonius, persirgusius galvos smegenų insultu, dažnai vargina pažinimo funkcijų sutrikimai. Psichomotorinės reakcijos laikas yra vienas rodyklių, rodančių pacientų pažinimo funkcijas.

**Darbo tikslas.** Įvertinti persirgusiųjų galvos smegenų insultu pažinimo funkcijų ir psichomotorinių reakcijų sutrikimus bei reabilitacijos veiksmingumą. Tiriamųjų kontingentas – 30 ligonių 65,33±13,2 metų, persirgusių

galvos smegenų insultu ir gydymų neuroreabilitacijos skyriuje. Ligonių pažinimo funkcijas vertinome trumpu protinės būklės vertinimo tyrimu ir neurobiheviuoristiniu pažinimo būklės tyrimu. Pacientų rankos raumenų jėgą matavome dinamometru. Psichomotorinės reakcijos laiką į šviesą ir garsą bei judesių dažnį vertinome reakciometru. Nustatėme, kad po reabilitacijos statistiškai reikšmingai pagerėjo pacientų pažinimo funkcijos. Vertinant trumpu protinės būklės tyrimu, pokytis sudarė  $6,4 \pm 2,3$  balo, vertinant neurobiheviuoristiniu pažinimo būklės tyrimu –  $13,3 \pm 10$  balo ( $p < 0,05$ ). Reabilitacijos pradžioje labiausia buvo sutrikusi pacientų atmintis, konstrukciniai gebėjimai, orientacija. Reabilitacijos pabaigoje nustatytas visų pažinimo funkcijų pagerėjimas. Taip pat nustatytas statistiškai reikšmingas pacientų reakcijos laiko bei judesių dažnio pokytis. Ankstyvosios reabilitacijos pabaigoje palyginus tiriamųjų ir atitinkamo amžiaus sąlyginai sveikų asmenų grupės reakcijos laiką, statistiškai reikšmingo skirtumo nenustatyta, todėl galime teigti, jog reabilitacijos metu funkcijos normalizavosi. Ankstyvosios reabilitacijos pradžioje ir po taikytos ergoterapijos nustatytas statistiškai reikšmingas vidutiniškai stiprus ryšys tarp pacientų protinės būklės ir psichomotorinės reakcijos laiko.

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