Impact of a Rehabilitation Program on the Change in Components of Body Mass of the Upper and Lower Limbs in People After Ischemic Stroke

ACDF 1
Grzegorz Przysada

ABEF 2
Justyna Leszczak

CDE 2
Joanna Baran

BDF 2
Andżelina Wolan-Nieroda

CDE 3
Bogumiła Pniak

BDF 4
Viliam Knap

ADF 2
Mariusz Drużbicki

ADE 2
Agnieszka Guzik

Corresponding Author: Justyna Leszczak, e-mail: leszczakjustyna.ur@gmail.com

Financial support: None declared
Conflict of interest: None declared

Background: The aim of this study was to evaluate the effects of rehabilitation in terms of changes in the body mass composition in the upper and lower limbs depending on the length of time after stroke and the age of the patient.

Material/Methods: Eighty-two patients after ischemic stroke were tested 3 times: on admission, after 5 weeks, and 3 months after leaving the hospital (follow-up). During each examination, a segmental analysis of the components of the body mass of the upper limbs and lower limbs was performed, depending on the side of paresis.

Results: Patients between 7 and 12 months after stroke with right-sided paresis had a reduction of fat ($P=0.027$) and an increase in muscle tissue in the lower ($P=0.030$) and upper limbs with paresis ($P=0.037$), as well as in the healthy upper limb ($P=0.034$) after rehabilitation. Only in the youngest age group (25-44 years) and in patients with left-sided paresis was there a decrease of adipose tissue in the healthy upper ($P=0.012$) and paresis limbs ($P=0.032$) and an increase in the muscle tissue mass in the right upper limb ($P=0.010$) after rehabilitation.

Conclusions: The rehabilitation program had a significant impact on the change in the composition of body mass in upper and lower limbs in people with right-sided paresis, particularly 7 to 12 months after stroke and in the youngest age group (25-44 years). These results may be useful in planning a rehabilitation program for stroke patients to consider the patient’s dominant hand and neglect.

Keywords: Adipose Tissue • Body Composition • Follow-Up Studies • Ischemic Stroke • Neoplasms, Muscle Tissue • Paresis • Rehabilitation

Full-text PDF: https://www.medscimonit.com/abstract/index/idArt/936397

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

This work is licensed under Creative Common Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0)
Stroke is currently an increasingly common cause of permanent disability worldwide. A stroke incident leads to permanent disability, with people often requiring assistance from third parties after stroke, and can even lead to death [1,2].

Worldwide, approximately 17 million people have a stroke each year, and in Poland the incidence of ischemic stroke is estimated at around 90,000 cases [3]. Stroke is the second most common cause of death in the world after ischemic heart disease and is often associated with various long-term physical and neuropsychological consequences [4-6]. Despite the decrease in mortality due to stroke observed in recent years, the global burden of stroke is increasing. A more comprehensive approach to primary stroke prevention is needed as is the timely start of comprehensive rehabilitation [7,8].

The literature points out that the body mass composition of patients after stroke should also be considered in the rehabilitation process [9,10]. Early rehabilitation allows for the return of lost functions by, among other things, faster muscle mass growth [11]. After a stroke, there is a reduction in muscle mass, loss of fat-free mass and bone mineral content, and increased adipose tissue (fat) [12,13]. This results in a reduction in functional efficiency in patients after stroke. It is also interesting that few researchers note in their reports that stroke and hemiparesis are associated with changes in the body composition of the limbs, especially bone and fat-free mass. They show that a stroke is likely to cause an increase in the fat mass of the trunk, but not in the limbs [14].

Studies indicate that the greatest progress in the recovery of functional fitness can be expected in the early period after stroke, when patients often show a significant improvement in neuromotor functions [15,16], this process slows down later, and patients tend to present persistent patterns [17,18]. Nevertheless, numerous studies have reported that inter-neuronal connections can be continuously remodelled by physiological activity, and that brain plasticity can be increased through various types of training [19-22]. Moreover, age has also been reported to influence the achievement of positive brain plasticity results during motor training [23].

There are reports in the literature on the effects of rehabilitation depending on the time after stroke [24,25] or age [26-29], and to the best of our knowledge, there are no studies on the effects of rehabilitation in terms of changes in the body mass composition depending on the length of time after stroke and patient age. Therefore, the aim of the study was to evaluate the effects of rehabilitation in terms of changes in the body mass composition in the upper and lower limbs depending on time after stroke and age of the patients.

### Material and Methods

#### Type of Study

This was a prospective observational study. The study was conducted in accordance with the Helsinki Declaration, and it was approved by the local bioethics commission (approval no. 2015/10/03). Written consent was obtained from all participants in the study.

#### Participants and Inclusion and Exclusion Criteria

During the research period, 403 patients after stroke were in the Rehabilitation Clinic’s Early Neurological Rehabilitation Unit. Prior to the study, a sample size was calculated from the 403 patients who were in the clinic during this period. With a 95% confidence interval, a significance level of 0.05, and a maximum error of 10%, it was calculated that the minimum sample size should be 78. Considering the inclusion and exclusion criteria, the study included 82 patients after ischemic stroke staying in the Rehabilitation Clinic’s Early Neurological Rehabilitation Unit.

The inclusion criteria for the entire study group were as follows: diagnosis of ischemic stroke, first complete stroke, the ability to stand without assistance, walking independently without the help of other people (including a doctor, nurse, physiotherapist) or with a little ankle-foot orthosis type support, no impairment of higher mental functions, right-handedness, completion of a 5-week inpatient rehabilitation program, informed consent to participate in the study, and age ≥25 years.

The inclusion criteria in examination III (follow-up) were as follows: physical activity measured by the self-report physical activity questionnaire (SPAQ) at a low-intensity level, not using additional rehabilitation between examination II and examination III, and appearing for a follow-up visit 3 months after discharge from the hospital.

The exclusion criteria for the whole study group were as follows: lack of consent of the patient to participate in the study, incomplete stroke (e.g., transient ischemic attack), hemorrhagic stroke, second or subsequent stroke, inability to stand independently (balance disorders and dizziness), ischemic lesion located in the cerebellum and brainstem, electronic implants, epilepsy, pregnancy, menstruation in women, and leg injuries after stroke.

#### Measurements

Patients were divided into 4 age groups: young age was from 25 to 44 years, middle age was from 44 to 60 years, elderly age was 60 to 75 years, senile age was ≥75 years [30]. Considering
the time since stroke in the study group, there were patients who were in the early and late periods after stroke. In assessing the effects of rehabilitation on changes in the body mass of the upper and lower limbs depending on the time after stroke, the group of patients was divided according to time after stroke as follows: 2 to 3 months, 4 to 6 months, 7 to 12 months, and >12 months [31]. Patients were also divided by sex (Table 1).

The body mass composition of patients was evaluated with the 780 MA Tanita MC analyzer, which is based on the measurement of electrical bioimpedance [32,33]. The analyzer is able to carry out a segmental body assessment, including of adipose tissue (fat) and muscle mass, which is divided into right and left arm, right and left leg, and trunk. The body height was measured to within 0.1 cm using the portable PORTSTAND 210. Measurements were made under standard conditions. Patients wore underwear and no shoes and were instructed to assume an upright posture. The analyzer is approved for medical use and meets the Non-Automatic Weighing Instrument Class III standards for scales used for medical measurements. The analyzer has European Union CE0122 certification. With regard to medical devices, it meets the requirements of the Medical Device Directive 93/42/EEC.

### Procedure

All patients participated in a 5-week rehabilitation program that lasted 5 days a week, from Monday to Friday. The rehabilitation program was based on neurodevelopmental methods, gait and upper limb training, as well as exercises on equipment using biological feedback and static and dynamic parapodium. The tests were performed 3 times: the first test (examination I) was performed at admission to the clinic prior to rehabilitation. A second test (examination II) was performed at discharge after 5 weeks of hospital rehabilitation. The third test (examination III) was performed as a follow-up 3 months after leaving the clinic during a follow-up visit.

After examination II, rehabilitation activities were limited to the recommendations that the patients and family members received upon discharge from the therapeutic team; the patients did not use additional rehabilitation in the period between examinations II and III. An additional recommendation was to maintain physical activity at least at a low-intensity level, including basic everyday activities, light housework, light gardening, grocery shopping, and leisurely walks (according to the SPAQ) [34,35].

Inclusion criteria were developed for all 3 examinations (examination I, examination II, examination III), and additionally (and separately) for examination III (follow-up), with a 3-month interval between measurement II and measurement III.

### Table 1. Characteristics of the study group.

| Variable            | N   | %   |
|---------------------|-----|-----|
| Place of residence  | Urban area | 42  | 52.5% |
|                     | Rural area | 38  | 47.5% |
| Sex                 | Female | 36  |       |
|                     | Male    | 44  | 54.9% |
| Age                 | 25-44 years | 11  | 13.7% |
|                     | 45-60 years | 28  | 35.1% |
|                     | 61-75 years | 30  | 37.5% |
|                     | >75 years | 11  | 13.7% |
| Time from stroke    | 2-3 months | 11  | 13.7% |
|                     | 4-6 months | 8   | 10.0% |
|                     | 7-12 months | 15  | 18.7% |
|                     | >12 months | 45  | 54.9% |
| Side of paresis     | Left   | 40  | 50.0% |
|                     | Right  | 40  | 50.0% |
| Education           | Primary | 7   | 8.8%  |
|                     | Secondary | 31  | 38.7% |
|                     | Vocational | 29  | 36.25% |
|                     | Higher  | 13  | 16.2% |
Table 2. The effect of rehabilitation on the amount of fat in age groups 25 to 44 and 45 to 60 years.

| Age         | Side of paresis | Exam | N   | Mean* | Median* | Q1-Q3* | SD | P     | Mean* | Median* | Q1-Q3* | SD | P     | Mean* | Median* | Q1-Q3* | SD | P     |
|-------------|-----------------|------|-----|-------|---------|--------|-----|-------|-------|---------|--------|-----|-------|-------|---------|--------|-----|-------|
|             |                 |      |     | FAT right lower limb | FAT left lower limb | FAT right arm | FAT left arm |
|             |                 |      |     |       |         |        |     |       |       |         |        |     |       |       |         |        |     |       |
| 25-44 years | Left            | Exam I | 5  | 27.18 | 3.88   | 0.093 | 17.62 | 3.88 | 0.550 | 15.00 | 9.71   | 0.407 | 15.81 | 8.25 | 0.012 | 14.35 | 8.05   | 0.032 |
|             |                 | Exam II | 5  | 20.44 | 9.60   |        | 15.41 | 8.87 |        | 15.27 | 9.28   |        | 14.39 | 7.90 |        | 13.51 | 8.17   |        |
|             | Right           | Exam I | 6  | 26.42 | 7.06   | 0.737 | 17.06 | 6.90 | 0.572 | 17.32 | 8.36   | 0.683 | 15.66 | 9.10 | 0.133 | 14.46 | 10.85  | 0.606 |
|             |                 | Exam II | 6  | 24.50 | 9.08   |        | 20.28 | 8.94 |        | 19.08 | 7.16   |        | 14.19 | 8.97 |        | 14.23 | 10.29  |        |
|             |                 | Exam III | 6  | 24.43 | 9.44   |        | 18.46 | 7.70 |        | 17.99 | 7.14   |        | 15.23 | 6.27 |        | 14.59 | 6.04   |        |
| 45-60 years | Left            | Exam I | 16 | 25.86 | 8.06   | 0.988 | 14.88 | 7.79 | 0.495 | 14.70*| 9.25*  | 0.064 | 12.38*| 8.44*| 0.173 | 13.28*| 9.59*  | 0.859 |
|             |                 | Exam II | 16 | 25.81 | 8.35   |        | 16.93 | 8.00 |        | 15.29*| 11.46* | 0.208*| 14.25*| 9.07*| 0.173 | 13.34*| 9.60*  | 0.173 |
|             | Right           | Exam I | 12 | 24.55 | 4.75   | 0.938 | 17.90 | 6.37 | 0.334 | 13.91*| 11.96* | 1.00  | 12.79 | 3.39 | 0.905 | 13.37 | 3.81   | 0.070 |
|             |                 | Exam II | 12 | 24.41 | 4.30   |        | 15.49 | 4.38 |        | 13.67*| 12.37* | 0.16* | 12.86 | 4.05 |        | 12.75 | 3.96   |        |
|             |                 | Exam III | 12 | 24.42 | 4.47   |        | 15.97 | 6.10 |        | 15.38 | 6.03   |        | 13.50 | 5.57 |        | 13.36 | 6.35   |        |

* Median (Q1-Q3); ** Wilcoxon test; *** T-test.

Statistical Analysis

The results are presented using descriptive statistics (mean, standard deviation, quartile). When analyzing the differences between the dependent variables, the t-test for dependent samples was used, after prior verification of the normality of the distributions of the variables with the Kolmogorov-Smirnov test. Correlations between the variables were assessed by the Pearson correlation coefficient. A significance level of P<0.05 was used. The calculation was performed with the STATISTICA package version 10.0 (StatSoft).
Table 3. The effect of rehabilitation on the amount of fat in age group 61 to 75 and >75 years.

| Age          | Side of paresis | Exam | N   | Mean median* | Q1-Q3* | SD  | P   | Mean median* | Q1-Q3* | SD  | P   | Mean median* | Q1-Q3* | SD  | P   | Mean median* | Q1-Q3* | SD  | P   |
|--------------|-----------------|------|-----|--------------|--------|-----|-----|--------------|--------|-----|-----|--------------|--------|-----|-----|--------------|--------|-----|-----|
|              |                 |      |     | FAT          | FAT right lower limb |          |     | FAT left lower limb |          |     | FAT right arm |          |     | FAT left arm |          |     |     |
| 61-75 years  | Left Exam I     | 12   | 27.85 | 7.22 | 0.443  | *** |     | 21.61 | 6.95 | 0.129 | *** | 14.79 | 4.37 | 0.34 | *** | 13.20 | 5.05 | 0.867 | *** |
|              | Left Exam II    | 12   | 25.81 | 3.98 |        |     |     | 17.21 | 5.38 |        |     | 15.75 | 12.72 | 0.92 | **  | 13.14 | 4.96 |        |     |
|              | Right Exam I    | 18   | 24.03 | 7.59 | 0.517  | *** |     | 16.67 | 7.70 | 0.663 | *** | 17.63 | 11.57 | 0.75 | **  | 13.98 | 11.43 | 0.509 | *** |
|              | Right Exam II   | 18   | 25.72 | 6.82 |        |     |     | 17.86 | 7.73 |        |     | 16.58 | 11.57 | 0.75 | **  | 13.52 | 11.01 | 0.937 | *** |
|              | Follow-up Left  | 12   | 25.81 | 3.98 | 0.988  | *** |     | 17.21 | 5.38 | 0.051 | *** | 17.46 | 5.38 | 0.066 | *** | 13.14 | 4.96 | 0.218 | *** |
|              | Follow-up Right | 18   | 25.72 | 6.82 | 0.197  | *** |     | 17.86 | 7.73 | 0.619 | *** | 17.67 | 7.63 | 0.626 | *** | 15.82 | 7.33 | 0.934 | *** |
| >75 years    | Left Exam I     | 6    | 27.20 | 8.80 | 0.780  | *** |     | 17.99 | 9.22 | 0.509 | *** | 22.08 | 7.82 | 0.917 | *** | 17.90 | 7.37 | 0.689 | *** |
|              | Left Exam II    | 6    | 28.85 | 7.01 |        |     |     | 21.62 | 8.02 |        |     | 22.13 | 6.97 | 0.917 | *** | 17.67 | 6.93 |        |     |
|              | Right Exam I    | 5    | 32.26 | 5.34 | 0.587  | *** |     | 23.58 | 7.98 | 0.801 | *** | 21.75 | 9.96 | 0.662 | *** | 18.74 | 8.76 | 0.258 | *** |
|              | Right Exam II   | 5    | 28.99 | 9.98 |        |     |     | 22.07 | 9.09 |        |     | 21.64 | 9.88 | 0.935 | *** | 18.26 | 8.38 |        |     |
|              | Follow-up Left  | 6    | 28.85 | 7.01 | 0.667  | *** |     | 21.62 | 8.02 | 0.580 | *** | 22.13 | 6.97 | 0.661 | *** | 17.67 | 6.93 | 0.599 | *** |
|              | Follow-up Right | 6    | 28.49 | 7.53 | 0.819  | *** |     | 22.07 | 9.09 | 0.924 | *** | 21.64 | 9.88 | 0.935 | *** | 18.26 | 8.38 | 0.904 | *** |

* Median (Q1-Q3); ** Wilcoxon test; *** T-test.

Results

The change in fat content of the patients was analyzed as a whole and divided into lower right, lower left, upper right, and upper left limbs, taking into account the age of the patients and the side of the paresis. It was noted that people with left-sided paresis who were in the youngest age group (25-44 years) had a reduction in the fat content of the healthy (P=0.012) and paresis upper limbs (P=0.032; Table 2). In older age groups, there was no statistically significant change in fat content between examinations I and II and examinations II and III (Table 3). In view of the patients’ fat content, it was noted that in left-sided paresis in the youngest age group (25-44 years), the muscle tissue content in the upper right...
Table 4. The effect of rehabilitation on the amount of muscle mass in age groups 25 to 44 and 45 to 60 years.

| Age     | Side of paresis | Exam | N   | Mean* | Median* | SD* | Q1-Q3* | P     | Mean* | Median* | SD* | Q1-Q3* | P     | Mean* | Median* | SD* | Q1-Q3* | P     |
|---------|-----------------|------|-----|-------|---------|-----|--------|-------|-------|---------|-----|--------|-------|-------|---------|-----|--------|-------|
|         |                 |      |     |       |         |     |      |       |       |         |     |      |       |       |         |     |      |       |       |
|         |                 |      |     |       |         |     |      |       |       |         |     |      |       |       |         |     |      |       |       |
| 25-44 years | Left            | Exam I | 5   | 69.20 | 3.74   | 0.096 |        |       | 40.02 | 2.00   | 0.527 |        |       | 41.38 | 4.72   | 0.552 |        |       | 40.95 | 3.88   | 0.010 |        |       | 41.75 | 3.78   | 0.265 |        |       |
|         |                 | Exam II | 6   | 69.88 | 6.66   | 0.732 |        |       | 40.32 | 3.44   | 0.577 |        |       | 39.21 | 3.66   | 0.674 |        |       | 41.10 | 4.33   | 0.207 |        |       | 41.50 | 5.29   | 0.560 |        |       |
|         |                 | Exam III | 5   | 75.58 | 9.19   | 0.701 |        |       | 41.18 | 4.35   | 0.672 |        |       | 41.28 | 4.53   | 0.666 |        |       | 41.68 | 3.69   | 0.737 |        |       | 41.97 | 3.67   | 0.779 |        |       |
|         |                 | Right   | Exam I | 6   | 71.73 | 8.64   | 0.443 |        |       | 38.74 | 4.44   | 0.651 |        |       | 39.30 | 3.56   | 0.741 |        |       | 41.75 | 4.51   | 0.883 |        |       | 41.63 | 5.03   | 0.990 |        |       |
|         |                 | Exam II | 6   | 71.73 | 6.44   | 0.443 |        |       | 38.74 | 4.44   | 0.651 |        |       | 39.30 | 3.56   | 0.741 |        |       | 41.75 | 4.51   | 0.883 |        |       | 41.63 | 5.03   | 0.990 |        |       |
|         |                 | Exam III | 6   | 78.81 | 24.78 | 0.443 |        |       | 39.65 | 3.76   | 0.651 |        |       | 39.90 | 3.49   | 0.741 |        |       | 41.36 | 3.03   | 0.883 |        |       | 41.67 | 2.94   | 0.990 |        |       |

Follow-up

| Age     | Side of paresis | Exam | N   | Mean* | Median* | SD* | Q1-Q3* | P     | Mean* | Median* | SD* | Q1-Q3* | P     | Mean* | Median* | SD* | Q1-Q3* | P     |
|---------|-----------------|------|-----|-------|---------|-----|--------|-------|-------|---------|-----|--------|-------|-------|---------|-----|--------|-------|
|         |                 |      |     |       |         |     |      |       |       |         |     |      |       |       |         |     |      |       |       |
|         |                 |      |     |       |         |     |      |       |       |         |     |      |       |       |         |     |      |       |       |
| 45-60 years | Left            | Exam I | 16  | 70.44 | 7.67   | 0.973 |        |       | 41.44 | 3.83   | 0.482 |        |       | 41.62 | 3.73-44.17* | 0.077 |        |       | 42.58 | 40.70-44.34* | 0.278 |        |       | 42.26 | 40.73-44.04* | 0.929 |        |       |
|         |                 | Exam II | 16  | 70.54 | 7.86   | 0.973 |        |       | 40.39 | 3.91   | 0.482 |        |       | 41.31 | 38.45-43.13* | 0.379 |        |       | 41.75 | 40.08-44.64* | 0.786 |        |       | 42.31 | 40.14-43.96* | 1.301 |        |       |
|         |                 | Right   | Exam I | 12  | 71.64 | 4.54   | 0.925 |        |       | 39.91 | 3.10   | 0.327 |        |       | 41.90 | 40.08-42.95* | 0.859 |        |       | 42.28 | 4.16-4.93* | 0.823 |        |       | 41.94 | 1.93-4.93* | 0.051 |        |       |
|         |                 | Exam II | 12  | 71.79 | 4.07   | 0.925 |        |       | 41.11 | 2.20   | 0.327 |        |       | 41.92 | 39.75-42.68* | 0.859 |        |       | 42.22 | 1.99-4.22* | 0.823 |        |       | 41.30 | 1.99-4.22* | 0.051 |        |       |
|         |                 | Exam III | 12  | 76.11 | 17.91 | 0.925 |        |       | 40.90 | 3.00   | 0.327 |        |       | 41.17 | 3.04-4.22* | 0.859 |        |       | 41.91 | 1.99-4.22* | 0.823 |        |       | 42.01 | 1.99-4.22* | 0.051 |        |       |

Follow-up

(healthy) limb (P=0.010) was increased after rehabilitation. In addition, the control study found a decrease in the overall muscle tissue content, including in people with left-sided paresis (P=0.049; Table 4).

Results of the follow-up examination showed that in people with left-sided paresis at the age of 61 to 75 years, the muscle content of the healthy lower limb was significantly reduced (P=0.048; Table 5).

The changes in body mass of the persons after stroke were then analyzed and considered the time elapsed since the stroke incident and the side of paresis. We found that in the period from 2 to 3 months after stroke and with left-sided paresis.
Table 5. The effect of rehabilitation on the amount of muscle mass in age groups 61 to 75 and >75 years.

| Age        | Side of paresis | Exam | N   | Mean | Median* | Q1-Q3* | Mean | Median* | Q1-Q3* | Mean | Median* | Q1-Q3* | Mean | Median* | Q1-Q3* | Mean | Median* | Q1-Q3* | Mean | Median* | Q1-Q3* |
|------------|----------------|------|-----|------|---------|--------|------|---------|--------|------|---------|--------|------|---------|--------|------|---------|--------|------|---------|--------|
|            |                |      |     |      |         |        |      |         |        |      |         |        |      |         |        |      |         |        |      |         |        |
| After rehab | Left           | Exam I | 12  | 68.54| 6.87   | 0.449  | 38.09| 3.41    | 0.136  | 41.45| 3.74    | 0.260  | 41.14| 3.24    | 0.495  | 41.45| 2.66    | 0.224  |
|            |                | Exam II | 18  | 72.16| 7.21   | 0.516  | 40.54| 3.80    | 0.651  | 40.08| 3.75    | 0.820  | 42.01| 3.98    | 0.551  | 42.33| 4.07    | 0.937  |
|            | Right          | Exam I | 18  | 70.55| 6.47   | 0.448  | 39.94| 3.80    | 0.637  | 40.64| 3.79    | 0.406  | 39.58| 3.12    | 0.448  | 40.25| 4.00    | 0.436  |
|            |                | Exam II | 18  | 73.62| 16.76  | 0.448  | 39.23| 4.08    | 0.637  | 39.32| 4.18    | 0.648  | 40.87| 3.65    | 0.664  | 40.54| 4.11    | 0.664  |
| Follow-up  | Left           | Exam I | 6   | 69.12| 8.40   | 0.781  | 39.97| 4.53    | 0.492  | 38.89| 3.81    | 0.926  | 40.03| 3.45    | 0.670  | 39.25| 4.27    | 0.303  |
|            |                | Exam II | 6   | 67.56| 6.67   | 0.781  | 38.10| 3.94    | 0.637  | 38.78| 3.38    | 0.648  | 40.15| 3.24    | 0.607  | 39.56| 3.95    | 0.397  |
|            | Right          | Exam I | 5   | 64.30| 5.07   | 0.584  | 37.18| 3.92    | 0.791  | 38.06| 4.89    | 0.445  | 38.52| 4.11    | 0.243  | 39.14| 4.34    | 0.071  |
|            |                | Exam II | 5   | 67.44| 9.51   | 0.584  | 37.95| 4.52    | 0.953  | 38.16| 4.92    | 0.951  | 39.76| 3.91    | 0.880  | 39.47| 4.35    | 0.770  |
| After rehab | Left           | Exam I | 6   | 67.56| 6.67   | 0.796  | 38.10| 3.94    | 0.574  | 37.87| 3.38    | 0.636  | 40.15| 3.24    | 0.591  | 39.56| 3.95    | 0.711  |
|            |                | Exam II | 6   | 65.43| 18.64  | 0.796  | 37.47| 3.42    | 0.637  | 37.34| 3.85    | 0.636  | 38.85| 2.80    | 0.636  | 38.85| 3.52    | 0.636  |
|            | Right          | Exam I | 5   | 67.44| 9.51   | 0.741  | 37.95| 4.52    | 0.953  | 38.16| 4.92    | 0.951  | 39.76| 3.91    | 0.880  | 39.47| 4.35    | 0.770  |
|            |                | Exam II | 5   | 64.58| 19.11  | 0.741  | 38.09| 4.34    | 0.953  | 38.31| 4.15    | 0.953  | 40.01| 2.68    | 0.953  | 40.21| 3.34    | 0.953  |

* Median (Q1-Q3); ** Wilcoxon test; *** T-test.

There was a reduction in the content of adipose tissue in the paresis upper limb (P=0.047; Table 6).

Many more changes were seen among patients between 7 and 12 months after stroke. In patients with right-sided paresis, the fat content of the lower paresis limb (P=0.027), the upper paresis limb (P=0.023), and the healthy upper limb (P=0.033) decreased after rehabilitation. Among patients with left-sided paresis, an increase in the fat content of the lower paresis limb was observed (P=0.028). A similar result was observed in the lower healthy limb in patients who were at least 12 months after stroke (P=0.042). In the follow-up examination in people more than 12 months after stroke with left-sided paresis, the level of fat in the healthy lower limb increased (Table 7).
Table 6. The effect of rehabilitation on the amount of fat at 2 to 3 and 4 to 6 months after stroke.

| Time after stroke | Side of paresis | Exam | N | Mean | SD | Median* | Q1-Q3* | P | Mean | SD | Median* | Q1-Q3* | P | Mean | SD | Median* | Q1-Q3* | P | Mean | SD | Median* | Q1-Q3* | P |
|-------------------|-----------------|------|----|------|----|---------|--------|---|------|----|---------|--------|---|------|----|---------|--------|---|------|----|---------|--------|---|------|----|---------|--------|---|
|                   |                 |      |    | FAT  |    | FAT right lower limb |       |   | FAT left lower limb |    | FAT right arm |       |   | FAT left arm |    |       |    |       |    |       |    |       |    |       |    |       |    |       |    |       |    |
| 2-3 months        | Left            | Exam I | 6  | 27.59 | 3.61 | 17.01 | 3.78 | 0.072 | 13.99 | 9.03 | 0.632 | 2.62 | 11.03* | 10.26-19.64 | 0.345 | 14.27 | 7.20 | 0.047 |
|                   |                 | Exam II | 6  | 21.62 | 9.06 | 15.55 | 7.94 |       | 15.12 | 8.30 |       | 2.38 | 12.78* | 9.68-17.54* |       | 13.59 | 7.31 |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
|                   | Left            | Exam I | 6  | 29.01 | 3.66 | 18.69 | 3.63 | 0.242 | 18.77 | 7.12 | 0.856 | 9.08 | 14.56 | 8.41 | 0.761 | 12.45 | 10.05 | 0.700 |
|                   |                 | Exam II | 6  | 23.49 | 8.75 | 19.37 | 8.05 |       | 18.82 | 6.99 |       | 9.84 | 14.36 | 9.06 |       | 12.55 | 9.77 |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
|                   | Left            | Exam I | 6  | 21.63 | 13.25 | 15.55 | 7.94 | 0.180 | 15.12 | 8.30 | 0.746 | 6.87 | 14.58 | 7.08 | 0.537 | 13.59 | 7.31 | 0.676 |
|                   |                 | Exam II | 6  | 21.93 | 28.40 |       |       |       | 17.22 | 7.79 |       | 7.22 |       |       | 11.51 | 7.92 |       | 11.13 | 8.99 |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
|                   | Right           | Exam I | 6  | 23.49 | 8.75 | 19.37 | 8.05 | 0.790 | 18.82 | 6.99 | 0.578 | 6.34 | 14.36 | 9.06 | 0.881 | 12.55 | 9.77 | 0.591 |
|                   |                 | Exam II | 6  | 23.40 | 9.12 |       |       |       | 16.95 | 6.98 |       | 6.84 | 15.16 | 6.26 |       | 15.55 | 5.79 |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| 4-6 months        | Left            | Exam I | 7  | 23.78 | 5.63 | 11.47 | 3.10 | 0.323 | 17.59 | 12.92 | 0.068 | 26.67 | 15.22* | 10.84-16.67* | 0.225 | 15.86 | 7.36 | 0.915 |
|                   |                 | Exam II | 7  | 26.46 | 7.66 |       |       |       | 18.12 | 7.74 |       | 22.09 | 15.65* | 12.82-22.97* |       | 15.80 | 6.56 |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
|                   | Left            | Exam I | 7  | 24.88 | 3.40-34.97 | 18.12 | 7.74 | 0.465 | 18.18 | 7.32 | 0.459 | 3.65 | 17.01 | 6.27 | 0.215 | 15.80 | 6.56 | 0.765 |
|                   |                 | Exam II | 7  | 27.29 | 23.25-34.97 |       |       |       | 15.63 | 7.12 |       | 7.34 | 12.36 | 5.99 |       | 14.85 | 6.78 |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
|                   | Right           | Exam I | 1  | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
|                   |                 | Exam II | 1  | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

* Median (Q1-Q3); ** Wilcoxon test; *** T-test.

The analysis of the change in muscle tissue content due to rehabilitation did not show any statistically significant changes in patients between 2 and 3 months after stroke, as well as in patients between 4 and 6 months after the onset of the stroke incident (Table 8).

In contrast, in patients between 7 and 12 months after stroke with right-sided paresis, an increase in muscle tissue content in the lower paresis limb (P=0.030), upper paresis limb (P=0.037), and healthy upper limb (P=0.034) was observed, which indicated a positive result of the rehabilitation. In people with left-sided paresis more than 12 months after stroke, muscle tissue was reduced in the healthy limbs (Table 9).
Table 7. The effect of rehabilitation on the amount of fat at 7 to 12 and >12 months after stroke.

| Time after stroke | Side of paresis | Exam | N | Mean median* | SD | Q1-Q3* | P | Mean median* | SD | Q1-Q3* | P | Mean median* | SD | Q1-Q3* | P | Mean median* | SD | Q1-Q3* | P |
|-------------------|----------------|------|---|--------------|----|--------|---|--------------|----|--------|---|--------------|----|--------|---|--------------|----|--------|---|
| 7-12 months       | Left           | Exam I | 8 | 27.21        | 10.18 | 0.716 | *** | 17.97        | 9.96 | 0.704 | *** | 13.18**       | 7.35- | 7.70* | 0.028 | 12.16        | 7.20 | 0.387 | *** |
|                   | Exam II        | 8   | 25.03        | 9.87 |         |     |       |    | 15.97        | 9.12 |         |     | 14.27**       | 9.31- | 22.73* | ** | 12.39        | 7.41 |         | *** |
|                   | Right          | Exam I | 7 | 22.75        | 4.86 | 0.625 | *** | 19.34        | 4.57 | 0.027 | *** | 14.04        | 3.85 | 0.456 | *** | 11.19        | 2.87 | 0.023 | *** |
|                   |                | Exam II | 7 | 21.78        | 1.84 |         |     | 13.86        | 3.85 |         |     | 13.81        | 3.73 |         | *** | 10.08        | 2.09 |         | *** |
|                   |                | Exam III | 7 | 21.66        | 2.49 |         |     | 16.31        | 5.84 |         |     | 15.76        | 5.55 |         | *** | 13.55        | 6.12 |         | *** |
| Follow-up         | Left           | Exam I | 8 | 25.03        | 9.87 | 0.563 |     | 15.97        | 9.12 | 0.999 | *** | 16.24        | 9.54 | 0.945 | *** | 12.39        | 7.41 | 0.678 | *** |
|                   | Exam II        | 8   | 25.48        | 9.42 |         |     |       |    | 15.98        | 6.90 |         |     | 16.40        | 6.91 |         | *** | 11.34        | 4.90 |         | *** |
|                   | Right          | Exam I | 7 | 21.78        | 1.84 | 0.826 | *** | 13.86        | 3.85 | 0.312 | *** | 13.81        | 3.73 | 0.472 | *** | 10.08        | 2.09 | 0.197 | *** |
|                   |                | Exam II | 7 | 21.66        | 2.49 |         |     | 16.31        | 5.84 |         |     | 15.76        | 5.55 |         | *** | 13.55        | 6.12 |         | *** |
|                   |                | Exam III | 7 | 21.66        | 2.49 |         |     | 16.31        | 5.84 |         |     | 15.76        | 5.55 |         | *** | 13.55        | 6.12 |         | *** |
| >12 months        | Left           | Exam I | 18 | 27.63        | 7.53 | 0.747 | *** | 20.40        | 7.70 | 0.509 | *** | 18.91**       | 12.59- | 24.38* | 0.307 | 14.76        | 6.14 | 0.680 | *** |
|                   | Exam II        | 18   | 26.83        | 5.19 |         |     |       |    | 18.68        | 6.49 |         |     | 18.72*        | 13.09- | 24.52* | ** | 14.65        | 5.90 |         | *** |
|                   | Right          | Exam I | 18 | 25.26        | 7.59 | 0.429 | *** | 16.99        | 8.29 | 0.411 | *** | 18.64**       | 12.69- | 25.95* | 0.493 | 14.04*        | 11.94- | 22.06* | 0.289 |
|                   |                | Exam II | 18 | 26.92        | 7.08 |         |     | 18.88        | 7.80 |         |     | 17.48**       | 12.44- | 23.65* | 0.493 | 14.29*        | 11.01- | 20.90* | 0.289 |
|                   |                | Exam III | 18 | 27.19        | 7.16 |         |     | 19.69        | 8.16 |         |     | 19.32        | 8.20 |         | *** | 16.07        | 7.16 |         | *** |
| Follow-up         | Left           | Exam I | 18 | 26.83        | 5.19 | 0.779 | *** | 18.68        | 6.49 | 0.042 | *** | 19.02        | 6.18 | 0.063 | *** | 14.65        | 5.90 | 0.167 | *** |
|                   | Exam II        | 18   | 26.70        | 6.01 |         |     |       |    | 21.90        | 7.64 |         |     | 21.80        | 7.51 |         | *** | 17.61        | 6.70 |         | *** |
|                   | Right          | Exam I | 18 | 26.92        | 7.08 | 0.190 | *** | 18.88        | 7.80 | 0.712 | *** | 18.35        | 7.66 | 0.667 | *** | 16.42        | 6.90 | 0.860 | *** |
|                   |                | Exam II | 18 | 27.19        | 7.16 |         |     | 19.69        | 8.16 |         |     | 19.32        | 8.20 |         | *** | 16.07        | 7.16 |         | *** |
|                   |                | Exam III | 18 | 27.19        | 7.16 |         |     | 19.69        | 8.16 |         |     | 19.32        | 8.20 |         | *** | 16.07        | 7.16 |         | *** |

* Median (Q1-Q3); ** Wilcoxon test; *** T-test.

Discussion

The aim of the study was to evaluate the effects of rehabilitation in terms of changes in the body mass composition in the upper and lower limbs depending on the length of time after stroke and the age of the patients. Currently, studies suggest that in patients after stroke, there is a change in body mass composition, such as adipose tissue, muscle tissue, fat-free tissue, and bone tissue, and in the amount of water content in the body [10,13,36,37].

After a stroke, especially in the acute period, sarcopenia can be noticed, with loss of muscle mass and strength. Stroke rehabilitation should therefore be introduced as soon as possible.
Table 8. The effect of rehabilitation on the amount of muscle mass at 2 to 3 and 4 to 6 months after stroke.

| Time after stroke | Side of paresis | Exam | N  | Mean median* | SD Q1-Q3* | Mean median* | SD Q1-Q3* | Mean median* | SD Q1-Q3* | Mean median* | SD Q1-Q3* | Mean median* | SD Q1-Q3* | Mean median* | SD Q1-Q3* |
|-------------------|----------------|------|----|-------------|-----------|-------------|-----------|-------------|-----------|-------------|-----------|-------------|-----------|-------------|-----------|
|                   |                |      |    | PMM left arm |           | PMM right lower limb |           | PMM left lower limb |           | PMM right arm |           | PMM left arm |           |           |           |
| 2-3 months        | Right         | Exam I | 6  | 68.81 | 3.48 | 0.074 | 40.32 | 1.93 | 0.603 | 41.87 | 4.39 | 0.289 | 42.95* | 43.59* | 0.345 | 41.73 | 3.38 | 0.145 |
|                   |               | Exam II | 6  | 74.47 | 8.66 |  *** | 41.11 | 3.89 | 0.86 | 41.34 | 4.06 | 0. *** | 42.33* | 43.75* | 0. *** | 41.96 | 3.28 | 0.088 |
| 4-6 months        | Right         | Exam I | 6  | 67.44 | 3.44 | 0.240 | 39.50 | 1.78 | 0.862 | 39.46 | 3.52 | 0.920 | 41.62 | 4.02 | 0.967 | 42.49 | 4.99 | 0.779 |
|                   |               | Exam II | 6  | 72.68 | 8.32 |  *** | 39.18 | 4.01 | 0.86 | 39.44 | 3.46 | 0. *** | 41.63 | 4.56 | 0. *** | 42.46 | 4.85 | 0.072 |
|                   | Right         | Exam III | 6  | 72.68 | 8.32 | 0.255 | 39.18 | 4.01 | 0.56 | 39.44 | 3.46 | 0.596 | 41.63 | 4.56 | 0.909 | 42.46 | 4.85 | 0.631 |
|                   |               | Exam III | 6  | 83.48 | 23.99 | 0.010 | 40.40 | 3.37 | 0.37 | 40.44 | 3.34 | 0.030 | 41.32 | 3.04 | 0.009 | 41.11 | 2.81 | 0.000 |

|                   | Right         | Exam I | 7  | 72.47 | 5.31 | 0.309 | 43.10 | 1.53 | 0.064 | 40.12* | 35.76-42.44* | 0.893 | 41.30* | 43.37-43.75* | 0.225 | 41.02 | 3.53 |
|                   |               | Exam II | 7  | 69.94 | 7.15 | 0.07 | 39.79 | 3.79 | 0.07 | 40.37* | 37.79-42.44* | 0.07 | 40.87* | 37.84-42.31* | 0.07 | 40.88 | 3.36 |

* Median (Q1-Q3); ** Wilcoxon test; *** T-test.

Body mass composition after ischemic stroke

This work is licensed under Creative Common Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0)

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

CLINICAL RESEARCH

Przysada G. et al: Body mass composition after ischemic stroke © Med Sci Monit, 2022; 28: e936397

* Median (Q1-Q3); ** Wilcoxon test; *** T-test.

to prevent worsening of muscle mass loss and strength function [37-39].

In the present study, the most positive changes were seen among people between 7 and 12 months after stroke with right-sided paresis. These changes included a reduction in fat content and an increase in muscle tissue in the lower and upper paresis limbs, as well as in the healthy upper limb after rehabilitation. We suppose that this may have been due to the fact that patients after stroke have already adopted a new life situation, have returned to the natural home environment, and have the greatest motivation for rehabilitation to regain their “old” life. It is worth emphasising that patients in the early post-stroke period often struggle with depression and reluctance to...
The effect of rehabilitation on the amount of muscle mass at 7 to 12 and >12 months after stroke.

| Time after stroke | Side of paresis | Exam | Mean | Median* | SD | Q1-Q3* | P | Mean | Median* | SD | Q1-Q3* | P | Mean | Median* | SD | Q1-Q3* | P | Mean | Median* | SD | Q1-Q3* | P | PMM | PMM right lower limb | PMM left lower limb | PMM right arm | PMM left arm |
|-------------------|----------------|------|------|---------|----|--------|---|------|---------|----|--------|---|------|---------|----|--------|---|------|---------|----|--------|---|-------|--------|----|---------------------|----------------|-------------|-------------|
| 7-12 months       | Left           | Exam I | 69.11 | 9.69 | 0.705 | 0.713 | *** | 39.93 | 4.90 | 0.713 | *** | 42.38* | 0.161 | 45.03* | 0.043 | 46.28 | 3.46 | 0.993 | 0.999 | 42.18 | 3.43 | 0.986 |
|                   | Exam II        | 71.27 | 9.34 | 0.620 | 0.620 | *** | 40.88 | 4.46 | 0.882 | *** | 41.80* | 0.140 | 37.54-44.17* | ** | 42.69 | 3.62 | *** | 0.037 | 0.034 | 42.19 | 3.37 | *** |
|                   | Exam III       | 73.34 | 6.46 | 0.620 | 0.620 | *** | 39.24 | 2.26 | 0.625 | *** | 41.89 | 1.95 | 0.625 | *** | 43.06 | 1.46 | 0.625 | 0.625 | 42.76 | 1.31 | 0.034 |
|                   | Exam IV        | 74.29 | 1.74 | 0.620 | 0.620 | *** | 41.94 | 1.95 | 0.625 | *** | 41.96 | 1.94 | 0.625 | *** | 43.53 | 1.20 | *** | 0.034 | 43.30 | 0.93 | *** |
|                   | Right          | Exam I | 62.96 | 19.40 | 0.375 | 0.375 | *** | 40.71 | 2.87 | 0.625 | *** | 40.94 | 2.78 | 0.625 | *** | 41.88 | 3.03 | 0.625 | 0.625 | 41.82 | 3.53 | 0.625 |

Follow-up

| Time after stroke | Side of paresis | Exam | Mean | Median* | SD | Q1-Q3* | P | Mean | Median* | SD | Q1-Q3* | P | Mean | Median* | SD | Q1-Q3* | P | Mean | Median* | SD | Q1-Q3* | P | PMM | PMM right lower limb | PMM left lower limb | PMM right arm | PMM left arm |
|-------------------|----------------|------|------|---------|----|--------|---|------|---------|----|--------|---|------|---------|----|--------|---|------|---------|----|--------|---|-------|--------|----|---------------------|----------------|-------------|-------------|
| >12 months        | Left           | Exam I | 68.73 | 7.17 | 0.753 | 0.753 | *** | 38.72 | 3.79 | 0.528 | *** | 39.40* | 0.140 | 36.88-42.47* | 0.280 | 41.50 | 2.88 | 0.614 | 0.614 | 40.71 | 3.33 | 0.093 |
|                   | Exam II        | 69.48 | 4.93 | 0.753 | 0.753 | *** | 39.54 | 3.22 | 0.528 | *** | 39.42* | 0.140 | 36.81-42.18* | ** | 41.58 | 2.76 | 0.614 | 0.614 | 40.95 | 3.11 | 0.093 |
|                   | Exam III       | 70.99 | 7.22 | 0.432 | 0.432 | *** | 40.38 | 4.08 | 0.410 | *** | 39.55* | 0.140 | 35.88-42.64* | 0.738 | 41.86* | 3.28 | 0.274 | 0.274 | 41.67* | 37.58* | 0.528 | 0.528 |
|                   | Exam IV        | 69.41 | 6.72 | 0.753 | 0.753 | *** | 39.44 | 3.83 | 0.724 | *** | 40.21* | 0.140 | 36.95-42.58* | 0.738 | 41.67* | 38.67-43.12* | 0.274 | 0.274 | 40.82* | 38.24-43.64* | 0.274 | 0.274 |

Follow-up

| Time after stroke | Side of paresis | Exam | Mean | Median* | SD | Q1-Q3* | P | Mean | Median* | SD | Q1-Q3* | P | Mean | Median* | SD | Q1-Q3* | P | Mean | Median* | SD | Q1-Q3* | P | PMM | PMM right lower limb | PMM left lower limb | PMM right arm | PMM left arm |
|-------------------|----------------|------|------|---------|----|--------|---|------|---------|----|--------|---|------|---------|----|--------|---|------|---------|----|--------|---|-------|--------|----|---------------------|----------------|-------------|-------------|
| >12 months        | Left           | Exam I | 69.48 | 4.93 | 0.553 | 0.553 | *** | 39.54 | 3.22 | 0.553 | *** | 39.38 | 3.04 | 0.553 | *** | 41.58 | 2.76 | 0.614 | 0.614 | 40.95 | 3.11 | 0.353 |
|                   | Exam II        | 67.40 | 14.53 | 0.674 | 0.674 | *** | 37.95 | 3.72 | 0.674 | *** | 37.99 | 3.67 | 0.674 | *** | 40.15 | 3.12 | 0.674 | 0.674 | 40.00 | 3.51 | 0.674 |
|                   | Exam III       | 69.41 | 6.72 | 0.674 | 0.674 | *** | 39.44 | 3.83 | 0.674 | *** | 39.71 | 3.79 | 0.674 | *** | 40.61 | 3.27 | 0.674 | 0.674 | 40.59 | 3.60 | 0.836 |
|                   | Exam IV        | 70.69 | 16.18 | 0.674 | 0.674 | *** | 39.07 | 4.04 | 0.674 | *** | 39.26 | 4.07 | 0.674 | *** | 40.86 | 3.32 | 0.674 | 0.674 | 40.81 | 3.79 | 0.674 |

* Median (Q1-Q3): ** Wilcoxon test; *** T-test.

Neglect is a common neuropsychological disorder after right hemisphere stroke, such as in people with left-sided paresis, and research indicates that neglect worsens the prognosis of functional recovery and causes poor rehabilitation outcomes [43-47]. In our present study, patients with right-sided paresis achieved the best results, which confirms the above theory, because all of our patients were right-handed; therefore, it can be assumed that when the early period of time has passed due to reduced motivation to exercise as a result of illness, their movement activity was intensified in the dominant right limb.
In turn, when analyzing the effects of age on the rehabilitation effects of body mass change, in our present study it was shown that only in the youngest age group (25-44 years) and with left-sided paresis, the fat content of the upper limb was reduced in the healthy and paresis limbs, and the muscle content of the upper right (healthy) limb was increased after rehabilitation. We suppose that this may be due to the fact that younger patients are, by definition, in better condition and more physically fit. Owing to the lower risk of age-related multi-disease burden and involutorial changes in particular systems of the human body in younger patients, they can achieve better rehabilitation results in terms of changes in body mass composition than the elderly after stroke. The elderly have senile processes in terms of all systems, including the musculoskeletal system, which is characterized by inter alia, muscle relaxation, weakening of muscle strength, and muscle atrophy and results from the poor condition of blood vessels causing poorer nutrition of the muscles. Studies have shown a decrease in body mass in elderly patients after stroke and a loss of muscle and fat mass [48-51]. This hypothesis was confirmed by the fact that our control study showed that in people with left-sided paresis at the age of 61 to 75 years, the muscle tissue content of the healthy lower limb significantly decreased, which may have been because elderly people who are older after a stroke often limit physical activity and mobility, which is due to limited activity and inactivity in all systems, including muscle tissue reduction [48-51]. Since the effects described above only applied to patients with left-sided paresis, and therefore to those whose dominant arm was the healthy one, it was likely because these patients already at the beginning had easier situations than patients with right-sided paresis, because they could become more involved in the exercise and work with the therapist, making the most of the dominant healthy upper limb in helping the other, the paresis limb, to work and exercise. In the available literature, there are few studies on the components of body mass in the upper limbs with paralysis among people after stroke that consider age and time from the onset of stroke. Knowing the content of muscle tissue and adipose tissue in the upper and lower limbs before the planned rehabilitation would allow for the targeting and selection of appropriate techniques, methods, and exercises for a patient’s condition.

It is also necessary to continue the research, while considering the segmental assessment of body mass composition.

**Limitations**

Despite our efforts, this study had certain limitations. First, the analysis was carried out only among patients who had ischemic stroke and only in right-handed patients. In subsequent studies, the group will be expanded to include patients with hemorrhagic stroke and left-handedness. The second limitation may be the segmental assessment of only the adipose and muscle tissue in the limbs of patients after a stroke with regard to age and time since stroke. However, the study did not consider the body mass composition of the whole body, owing to the isolation and evaluation of the effects of rehabilitation in terms of changes in the body mass composition in the upper and lower limbs. An interesting analysis could also be the assessment of the correlation between the body mass composition and the level of physical activity in patients after stroke. It would be worth considering the inclusion of such analysis in future studies.

**Conclusions**

The rehabilitation program has had a significant impact on the change in the composition of body mass in upper limbs and lower limbs in people with right-sided paresis, in particular 7 to 12 months after stroke. We suspect that this may have been because the patients were right-handed and therefore their exercise was intensified in the upper and lower right limbs. The results obtained may be useful in planning a rehabilitation program for stroke patients that considers the patient’s dominant side and neglect.

Under the influence of hospital rehabilitation in the youngest age group (25-44 years) muscle tissue growth was observed, and adipose tissue was reduced in the upper limbs in patients with left-sided paresis. This may indicate the need for specific activation of older people who are more likely to have co-existing diseases and lower functional efficiency than those of a younger age.

**References:**

1. The Lancet. 21st Century management and prevention of stroke. Lancet. 2018;392(10154):1167
2. Błażejewska-Hyżorek B, Członkowska A, Czernuszenko A, et al. Stroke management guidelines. Pol Przegl Neurol. 2019;15(Suppl. A):1-156
3. Filipka K, Skrzypek-Czerko M, Cwieka-Lewis K, Słusarz R. Clinimetric evaluation of functional capacity and quality of life of stroke patients – study review. I Neurol Neurosurg Nurs. 2019;8:86-90
4. Donkor ES. Stroke in the 21st Century: A snapshot of the burden, epidemiology, and quality of life. Stroke Res Treat. 2018;2018:3238165
5. NFZ on Health. Ischemic Stroke. (cited 2021 15 November). Available from: https://zdrowedane.nfz.gov.pl/pluginfile.php/202/mod_resource/content/1/utar_niedokrwieniny_mozgu_nfs_c_dzwoni.pdf 2019 [in Polish]
6. Hankey GJ. Stroke. Lancet. 2017;389:641-54
7. Coleman ER, Moudgal R, Lang K, et al. Early rehabilitation after stroke: A narrative review. Curr Atheroscler Rep. 2017;19:59
8. Irisawa H, Mizushima T. Correlation of body composition and nutritional status with functional recovery in stroke rehabilitation patients. Nutrients. 2020;12;1923
29. Wilczyński J, Pedrycz A, Mucha D, et al. Body posture, postural stability, and metabolic age in patients with Parkinson’s disease. Biomed Res Int. 2017;2017:3975417

30. Dyussembayev A. Age periods of human life. Adv Soc Sci Res J. 2017;4(6):2924

31. Dromerick AW, Geed S, Barth J, et al. Critical Period After Stroke Study (CPASS): A phase II clinical trial testing an optimal time for motor recovery after stroke in humans. Proc Natl Acad Sci USA. 2021;118(39):e2026676118

32. Leszczak J, Cenziecz-Lewandowska E, Przysada G, et al. Association between body mass index and results of rehabilitation in patients after stroke: A 3-month observational follow-up study. Med Sci Monit. 2019;25:4869-76

33. Anyżewska A, Lepionka T, Łakomy R, et al. Fat Mass Index and dietary behaviours of the Polish Border Guard officers. Rocz Panstw Zakl Hig. 2019;70:201-8

34. Phusuttatam T, Saengsuwan J, Kittipanya-Ngam P. Development and preliminary validation of a stroke physical activity questionnaire. Stroke Res Treat. 2019;2019:6764834

35. Potchana K, Saengsuwan J, Kittipanya-Ngam P. Validity and test-retest reliability of a thai stroke physical activity questionnaire. J Stroke Cerebrovasc Dis. 2021;30(8):105907

36. English C, Thoirs K, Coates A, Ryan A, Bernhardt J. Changes in fat mass in stroke survivors: A systematic review. Int J Stroke. 2012;7(6):491-98

37. Beaupre GS, Lew HL. Bone-density changes after stroke. Am J Phys Med Rehabil. 2006;85:464-72

38. Scharbakov N, Sandek A, Doehner W. Stroke-related sarcopenia: Specific characteristics. J Am Med Dir Assoc. 2015;16:272-76

39. Scharbakov N, von Haehling S, Anker SD, et al. Stroke-induced sarcopenia: Muscle wasting and disability after stroke. Int J Cardiol. 2013;170:89-94

40. Altieri M, Maestrini I, Mercurio A, et al. Depression after minor stroke: Prevalence and predictors. Eur J Neurol. 2012;19(3):517-21

41. Schöttke H, Giabboncini CM. Post-stroke depression and post-stroke anxiety: Prevalence and predictors. Int Psychogeriatr. 2015;27(11):1805-12

42. Jiang XG, Lin Y, Li YS. Correlative study on risk factors of depression among acute stroke patients. Eur Rev Med Pharmacol Sci. 2014;18(9):1315-23

43. Jehkonen M, Yliranta A, Rasimus S, Saunamäki T. [Neglect rehabilitation after stroke.]. Duodecim. 2013;129(9):506-13 [in Finnish]

44. Luukkainen-Markkula R, Tarkka IM, Pitkänen K, et al. Rehabilitation of hemispatial neglect: A randomized study using either arm activation or visual scanning training. Restor Neuro Neurosci. 2009;27(6):663-72

45. Matano A, Iosa M, Guaicalia C, et al. Does outcome of neuropsychological treatment in patients with unilateral spatial neglect after stroke affect functional outcome? Eur J Phys Rehabil Med. 2015;51(6):737-43

46. Chen P, Chen CC, Hreha K, et al. Kessler Foundation Neglect Assessment Process uniquely measures spatial neglect during activities of daily living. Arch Phys Med Rehabil. 2015;96(5):869-76.e1

47. van Wyk A, Eksteen CA, Rheeder P. The effect of visual scanning exercises integrated into physiotherapy in patients with unilateral spatial neglect poststroke: A matched-pair randomized controlled trial. Neurorehabil Neural Repair. 2014;28(9):856-73

48. Ha L, Hauge T, Iversen PO. Body composition in older acute stroke patients after treatment with individualized, nutritional supplementation while in hospital. BMC Geriatr. 2010;10:75

49. Bryningsen PK, Damsgaard EM, Husted SE. Improved nutritional status in elderly patients 6 months after stroke. J Nutr Health Aging. 2007;11(1):75-79

50. Irissawa H, Mizushima T. Correlation of body composition and nutritional status with functional recovery in stroke rehabilitation patients. Nutrients. 2020;12(7):1923

51. Vahlberg B, Lindmark B, Zetterberg L, et al. Body composition and physical function after progressive resistance and balance training among older adults after stroke: An exploratory randomized controlled trial. Disabil Rehabil. 2017;39(12):1207-14