

Does muscle strength decrease on the unaffected side in stroke patients?

The unaffected side in stroke patients

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Abstract

Aim: Muscle strength is necessary to overcome the resistance encountered during activity in stroke individuals. The present study aims to determine total muscle strength and muscle strength loss of unaffected side in stroke individuals.

Material and Methods: In this study, muscle strength and grip strength were evaluated using the Power Track II Commander dynamometer and Jamar Hand dynamometer, respectively. Thirty-three stroke individuals and 33 healthy individuals were compared to determine the total muscle strength. The total muscle strength of healthy individuals was calculated by summing the muscle strength of the trunk, lower and upper extremities. In addition, muscle strength of the trunk, unaffected upper and lower extremities was summed to calculate the total muscle strength of stroke patients. Twenty-seven stroke individuals and 33 healthy individuals were analyzed to compare muscle strength of unaffected sides between groups.

Results: The total muscle strength of stroke individuals and healthy individuals was 49909.5 N and 182375 N, respectively. The difference between groups was measured as 132465.5 N. The loss of total muscle strength in stroke patients was 72.63%. When comparing total muscle strength on the unaffected side, a significant difference was found in favor of healthy individuals ($p = 0.0001$).

Discussion: Loss of muscle strength on the unaffected side affects the patient's functionality. Therefore, this must be taken into consideration in physiotherapy programs.

Keywords

Muscle strength; Stroke rehabilitation; Unaffected side

DOI: 10.4328/ACAM.20559 Received: 2021-03-02 Accepted: 2021-04-24 Published Online: 2021-05-05 Printed: 2021-09-01 Ann Clin Anal Med 2021;12(9):1011-1015

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Introduction

Stroke is the most common neurological disorder in the world and the third cause of mortality in the United States and European countries [1]. After stroke, motor deficits are probably the most recognized impairments [2]. It was reported that stroke patients experience these deficits between 89.1% and 61.0% in the first 6 months period after stroke and may continue throughout life. Motor deficits can take various forms, but the muscle strength (MS) loss (maximum voluntary force or torque) is probably the most obvious clinical presentation [3]. MS loss is one of the important factors that affect recovery after stroke. The loss in MS obstacles proper posture and the come out of the functional movement [4]. MS must overcome the resistance encountered during the activity [5]. Therefore, loss in MS is one of the barriers to reach full independence in activities of daily living (ADL) in stroke individuals (SI) [3].

It has been shown that MS loss occurs generally on the contralateral (affected) side of the cerebral lesion in SI [6]. However, many studies are showing that MS loss, balance disturbances, coordination, somatosensory, perception, and executive function impairments are not only characterized in the contralateral side, but also in the ipsilateral (unaffected) side [7,8]. Although MS loss and motor impairments are shown to be bilaterally in SI, the amount of this loss was not objectively demonstrated. Besides, previous studies have only focused on specific muscle groups and did not examine the total MS loss. Determining the loss of total and unaffected side MS is important because of the muscle strength effect on functionality, daily living activity and balance [3]. This study aims to investigate the unaffected side MS and total MS loss in the SI.

Material and Methods

Participants

As a result of the power analysis, 66 people (33 for each group) were included in the study, with a power of 90% could be obtained with a confidence level of 95%. This study was included chronic phase (patients diagnosed with a stroke at least 6 months ago) SI between the ages of 30-65 who were treated in the department of the neurological rehabilitation unit of the university hospital. Also, individuals with ischemic stroke were included in the study. Individuals with additional to stroke neurological disease and individuals with orthopedic, mental and communication impairments that may affect assessment were excluded. In addition, SI who scored more than 3 points for the Modified Rankin Scale were excluded (Figure 1).

Individuals with orthopedic, metabolic, rheumatologic, mental and communication problems and active sporting life were excluded (Figure 1).

All procedures were in accordance with the Declaration of Helsinki. This study was approved by the Ethics and Human Research committee of Pamukkale University Hospital (Denizli, Turkey). IRB approval was obtained with the number of 60116787-020/8882. Each patient gave written informed consent.

Procedure

After demographic characteristics including age, body mass index (BMI), and medical status of participants (affected and

dominant side) were recorded, MS was measured using a Power Track II Commander dynamometer and recorded in Newton. Measurements were performed on both limbs and trunk muscles of the unaffected side in SI and on both side extremity and trunk muscles in HI. The upper extremity, lower extremity, and trunk muscles of SI and HI were evaluated in the muscle test position defined for the dynamometer, and isometric maximum resistance was recorded [9]. HI and SI had to generate maximum muscle force against a stationary dynamometer held by the therapist, and the muscle strength was measured in newton from the maximum reflection. The measurements were made three times with rest intervals and recorded by taking the average of all [10].

In both groups, the lower extremity total muscle strength was calculated by summing the strength of the hip flexor, extensor, internal rotator, external rotator, abductor, adductor, knee flexor, extensor, ankle plantar flexor, evertor, invertor muscles. Also, to calculate the upper extremity total muscle strength, the strength of shoulder flexor, extensor, abductor, adductor, horizontal abduction and adduction, external and internal rotator, scapular adductor, scapular adductor and down rotator, scapular depression and adductor, scapular elevation, elbow flexor extensor, wrist flexor, extension were summed; and, trunk extensor muscles were summed.

The Jamar Hand dynamometer was used to measure the grip strength. Measurements were done in a sitting position on a chair without arm support, with the shoulder in the adduction and neutral position, with the elbow at 90 degrees flexion, and the forearm and wrist in a neutral position. The measurements were made three times with rest intervals and recorded by taking the average of all [11].

The total MS was calculated by summing upper extremity total MS, lower extremity total MS, trunk extensor MS and grip strength of unaffected side in SI and both upper extremity total MS, lower extremity total MS, grip strength and trunk extensor strength in HI.

When comparing the unaffected side of SI, HI with right-side dominant and SI with right-side dominant and unaffected were matched. The data obtained from the right side of the HI group and the unaffected side of the SI group were compared.

Statistical analysis

The statistical package SPSS 21.00 for Windows (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Continuous variables were expressed as mean \pm standard deviation, median (minimum and maximum values) and categorical variables as numbers and percentages. All continuous variables were evaluated for normality using the Shapiro-Wilk test. Significant differences in quantitative demographics between groups were analyzed using an independent sample test (when the data are normally distributed), Mann-Whitney U test (when the data are non-normally distributed). Significant differences in qualitative demographics between groups were analyzed using the Chi-square test. The total MS of the upper extremity, the total MS of the lower extremity, grip strength data of groups were compared with the "Mann-Whitney U test" because of the non-normal distribution. Since Trunk extensor MS of groups were normally distributed, Trunk extensor MS were compared with the "Independent sample t-test". The MS data of the groups

were compared with the “Independent sample t-test” because of normal distribution. The level of significance was set at $p < 0.05$.

Results

This study was conducted in 33 SI [11 (33.3%) females, 22 (66.6%) males] and 33 HI [13 (39.4%) females, 20 (60.6%) males]. All stroke patients were in the chronic phase and had an ischemic stroke. In addition, the average duration of stroke from the onset was 1.23 ± 0.60 years. The average age was 56.33 ± 8.92 years in the SI group and 52.3 ± 8.52 years in the HI group. The body mass index (BMI) average was 27.23 ± 3.62 kg/m² in the SI group and 28.17 ± 4.56 kg/m² in the HI group. The dominant side of all SI was the right hand, the affected side (AS) of 27 SI was left and in the other 6 was right. There was no statistically significant difference between the groups in terms of gender, BMI ($p > 0.05$) (Table 1). There was a significant difference in favor of the SI group in terms of average age ($p < 0.05$) (Table 1).

Table 1. Sociodemographic - Clinical Features of Groups

	SI Group (n=33)	HI Group (n=33)	P
Age			
years	56.33 ± 8.92	52.3 ± 8.52	0.028*
Gender [n (%)]			
female	11 (33,3%)	13 (39,4%)	0.609**
male	22 (66,6%)	20 (60,6%)	
BMI			
kg/m ²	27.23 ± 3.62	28.17 ± 4.56	0.356***
Duration of Stroke			
years	1.23 ± 0.60	-	-
Dominant side			
right	33	33	-
left	-	-	-
Affected Side			
right	27	-	-
left	6	-	-

BMI: Body Mass Index; SI: stroke individuals; HI: healthy individuals
 *: Mann - Whitney U Test
 **: chi- squared test

Thirty-three HI with right-side dominant and 27 SI with right-side dominant and unaffected were matched. The data obtained from the right side of the HI group and the unaffected side of the SI group were compared. There were significant differences found in favor of HI in all values (upper extremity total MS, lower extremity total MS, Trunk extensor MS and grip strength) (Table 2).

The total upper extremity MS of the SI was 28202,5 N, and the total upper extremity MS of the HI was 115119 N. The difference between the total upper extremity MS of the HI and SI was 86916.5 N. On a percentage basis, the loss of MS was 75.50% in SI (Table 3).

The total lower extremity MS of the SI was 18989 N, and the total lower extremity MS of the HI was 75334 N. The difference between the total lower extremity MS HI, and SI was 56345 N. On a percentage basis, the loss MS was 77.79% in SI (Table 3).

Table 2. Comparison of MS Averages of Groups

Muscle groups	SI Group (Mean±SD)	HI Group (Mean±SD)	P
UETMS	617.63 ± 223.91	1154.48 ± 368.0	0.0001*
GS	42.74 ± 15.62	77.42 ± 24.95	0.0001*
LETMS	598.52 ± 212.28	1207.16 ± 328.48	0.0001*
Trunk extensor MS	91.12 ± 28.58	168.18 ± 45.99	0.0001**

SI: stroke individuals; HI: healthy individuals; UETMS: Upper extremity total muscle strength; LETMS: lower extremity total muscle strength; Trunk extensor MS: Trunk extensor muscle strength; GS: Grip strength; SD: standard deviation
 * Mann - Whitney U Test
 ** Independent Samples t- test

Table 3. Total MS Differences of Groups

	SI Group	HI Group	Difference	Percentage (%)
UETMS (N)	28202,5	115119	86916,5	75,50
LETMS (N)	18989	75334	56345	77,79
Trunk extensor MS (N)	2718	4090	1372	33,55
GS (N)	1484	5083	3599	70,80
TMS (N)	49909,5	182375	132465,5	72,63

N: Newton; SI: stroke individuals; HI: healthy individuals; UETMS: Upper extremity total muscle strength; LETMS: lower extremity total muscle strength; Trunk extensor MS: Trunk extensor muscle strength; GS: Grip strength; TMS: Total muscle strength

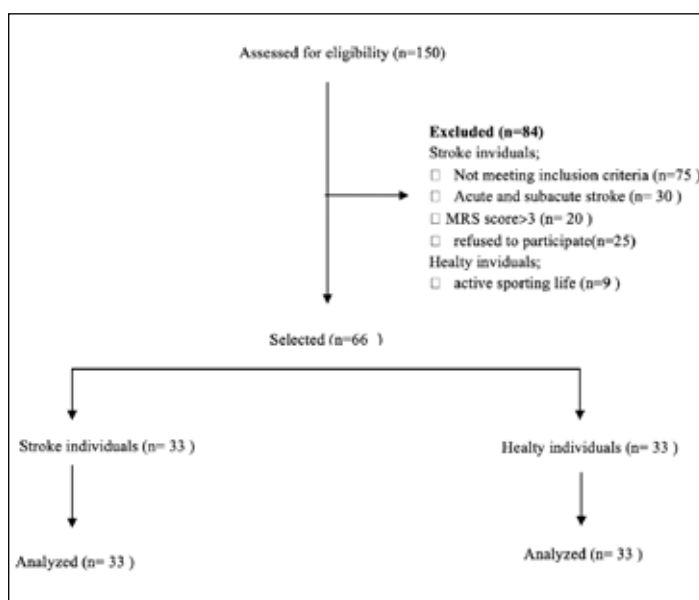


Figure 1. Flowchart of Stroke and Healthy Individuals Inclusion

The MS of trunk extensor of the SI was 2718 N and the MS of the trunk extensor of HI was 4090 N. The difference between the MS of trunk extensor of the HI and SI was 1372 N. On a percentage basis, the loss of MS was 33.55% in SI (Table 3). The grip strength of the SI was 1484 N, and the grip strength of HI was 5083 N. The difference between the grip strength of HI and SI was 3599 N. On a percentage basis, the loss in grip strength was 70.80 in SI (Table 3).

The total MS of the SI was 49909.5 N and the total MS of the HI was 182375 N. The difference between the total MS of the healthy and SI was 132465.5 N. On a percentage basis, the loss in total MS was found 72.63% in SI (Table 3).

Discussion

The aim of this study was to investigate unaffected side MS and total MS loss in the SI. The results of this study showed that unaffected side MS (upper extremity total MS, lower extremity total MS, grip strength, trunk extensor MS) of SI decreased dramatically compared to HI, and the total MS of SI decreased 72.63%.

The studies about MS, as one of the most important factors in preventing disability during stroke rehabilitation, are generally focused on the affected side of SI. But it may be hard to initiate and improve movement because of muscle weakness and spasticity. This situation may limit proper neuroplasticity response and cause maladaptive plasticity [12]. On the other hand, studies have shown that the findings in the cerebral cortex lesions are bilateral [13]. These results strengthen the idea that the unaffected side extremities may be affected. In accordance with all these studies, in our study, we found that the individuals with stroke have significantly decreased MS compared to HI. Therefore, we believe that it is necessary to improve MS of the unaffected side through the chronic stage to ensure full independence in ADL of SI.

Muscle mass, power and strength begin to decrease in the 3rd decade of life. Between 30 and 50 years of age, the reported decreases in muscle mass, power and strength are small. Pronounced decreases with the aging process occur after 50th year of life with more than 15% strength loss per decade [14]. In our study, we found that the average age of the stroke group was significantly higher than in the healthy group. The difference between the average age of the groups was 4 years. This may affect our result negatively. However, when we look at the MS values, we can see that this difference may not affect the results sharply.

The grip strength is robustly associated with mobility outcomes and is a relatively simple and inexpensive proxy of overall MS [15]. Grip strength is an important parameter of self-care ability and quality-of-life, and grip strength loss is associated with a reduction in self-care ability and quality-of-life; therefore, grip strength is important for the maintenance of ADL while eating, bathing or others [16]. But stroke patients have difficulty in performing these tasks due to strength insufficiency and spasticity. Therefore, the grip strength of the unaffected side plays an important role in performing these tasks. In accordance with our study, it was also stated in a few previous studies that the grip strength was affected in the unaffected side [7]. Additionally, our study revealed the rate of this loss as a percentage and showed how this problem is great. On the other hand, unilateral grip strength training improves the grip power bilaterally, and it is stated that such training may be used in neurological diseases like stroke to improve neuroplasticity [17].

SI has a motor impairment between 50%-75% in the affected upper extremity, and about 30% of this impairment cannot be fully recovered. The motor impairment of the ipsilesional side, also known as the unaffected side, has been investigated less and this impairment has not been elucidated yet. In a study, proximal and distal muscle strength of unaffected upper extremities of 72 SI was assessed from an early period. It was concluded that, although MS recovery reached a maximum level

within 1 month, the weakness did not completely disappear. Moreover, it was suggested that the proximal and distal upper extremity weakness in the unaffected side after stroke was not a transient event [18]. In another study, it was demonstrated that movement (especially in ADL), speed-related kinematic and movement quality are impaired clearly in unaffected side upper extremity in SI [19]. Our results, closely supported by the abovementioned studies, suggest that the unaffected side of MS should be improved through the chronic stage in patient with stroke to improve daily tasks such as drinking water, brushing teeth.

Although the weakness of the trunk MS in SI has been already mentioned, studies on the strength of the trunk muscles is scarce. Muscle weakness is observed more prominently in upper and lower extremities, because approximately 80% of them are innervated only by one hemisphere [20]. Since the nerves that innervate the trunk are controlled by both hemispheres of the brain, the muscle weakness in the trunk is seen less than the extremities [21]. The recovery of the trunk muscles starts from the early period. Although the weakness of trunk muscles is evident in the acute and subacute phases, it should be kept in mind that it can continue in the chronic phase [22]. In addition, the weakness of the trunk muscles not only covers the anterior trunk flexors, but also the trunk extensors and rotators. All trunk muscles play a very important role in protecting the body against gravity and providing proximal stabilization during functional activities. Adequate function of these muscles is very important for balance, transfer, walking, other functional activities and respiratory sufficiency [5,23]. Due to important functions of the trunk muscles, it is mandatory to evaluate and improve trunk MS of SI [24]. In our study, the decrease in trunk extensor MS was found to be less than the decrease in MS of extremities. In addition to the previous studies, our study revealed this loss as a percentage and clarified the importance of this topic. We think that clinicians, working in this field, should improve trunk MS from the early period and through chronic phase of the rehabilitation process to get better results rapidly.

Stroke is the main cause of disability in adults. The MS loss of lower limb is one of the main impairments that can be encountered after stroke [25]. It is also associated with a limited ability to perform activities of daily living such as walking [9]. In a systematic review including 5 studies, the MS of hip flexor, knee extensor and ankle dorsiflexor were examined. According to this review, all of the included studies found that MS of the unaffected side significantly decreased, with the exception of one study. As a result of this review, it was concluded that the MS of the US was decreased in SI, and this reduction was reported to be at least 10-13.4% (28). In the light of literature and our study, lower extremity MS, which forms the basis of ADL, should be improved on the affected and unaffected side. It was shown that the strength of wrist flexor muscle, wrist extension muscle, grip, finger flexion muscle, thumb flexion muscle, thumb extension muscle, elbow flexion muscle, elbow extension muscle, shoulder abduction muscle and shoulder adduction muscle were decreased by 68%, 57%, 66%, 64%, 59%, 58%, 53%, 47%, 43% and 37%, respectively in SI. In our study, we found that the loss of total MS in the upper extremity was 75.50% and in grip strength was 70.80%. This dramatic

loss of total MS has clearly demonstrated the negative impact of stroke on patients.

According to the results of our study, lower extremity MS decreased by 74.79%, trunk extensor MS by 33.55% and total MS by 72.63%. We could not find any study examining the percentage of loss of the lower extremity, trunk and total MS. These findings have been examined for the first time in the literature. Thus, our study is prominent in this field, and it is important to support it with new studies.

One limitation of our study was that the hands, toes and neck muscles strength could not be evaluated because the dynamometer was not compatible. Another limitation of the current study was that the MS of the AS was not measured in terms of muscle spasticity. However, in some individuals, little MS on the AS was observed. Examination of the muscle strength of AS by eliminating spasticity is important to obtain more objective results. In addition, studies to be conducted by increasing the sample group and using golden standard instrument methods will shed more light on this issue. Despite the limitations, our study objectively demonstrated the loss in total MS. In addition, our study showed that the muscle strength of the US reduced significantly.

In conclusion, our study showed that MS of unaffected side and total MS decreased dramatically in SI. As a result of our study, MS should be improved on both the affected and US in SI. In addition, we think that it may be more appropriate to use the term 'less AS' instead of the unaffected side.

Acknowledgment

The authors would like to thank all participants for their support.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

Funding: None

Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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How to cite this article:

Aziz Dengiz, Emre Baskan. Does muscle strength decrease on the unaffected side in stroke patients? *Ann Clin Anal Med* 2021;12(9):1011-1015