RESEARCH ARTICLE/ARAŞTIRMA MAKALESİ
Karya J Health Sci. 2024; 5(1): 22-27
doi: 10.52831/kjhs.1407836
e-ISSN:2717-9540

KARYA JOURNAL OF HEALTH SCIENCE

journal homepage: www.dergipark.org.tr/kjhs

INVESTIGATION OF THE RELATIONSHIP BETWEEN COGNITIVE LEVEL AND UPPER EXTREMITY FUNCTIONS IN PATIENTS WITH CHRONIC STROKE

KRONİK İNMELİ HASTALARDA KOGNİTİF DÜZEY İLE ÜST EKSTREMİTE FONKSİYONLARI ARASINDAKİ İLİŞKİNİN İNCELENMESİ

Hilal Aslan[1*], Emre Baskan[2]

[1]Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Ankara Yıldırım Beyazıt University, Ankara, Türkiye

[2]Faculty of Physiotherapy and Rehabilitation, Pamukkale University, Denizli, Türkiye

ABSTRACT

Objective: Cognitive impairment and loss of upper limb functions are common after stroke and these two components can influence each other in anatomical and functional contexts. In this study, it was aimed to examine the relationship between cognitive level and upper extremity functions in patients with chronic stroke.

Method: The study included 39 individuals diagnosed with stroke, in the chronic phase and with a mean age of 61.33±12.71 years, who were evaluated at Pamukkale University Hospital. Standardized Mini Mental Test (SMMT) and Stroop Test Basic Sciences Research Group (TBAG) Form were used to evaluate the cognitive levels of individuals. Fugl Meyer Upper Extremity Rating Scale, Frenchay Arm Test and Box-Block Test were used to evaluate upper extremity functions.

Results: When the findings of the study were examined, statistically significant relationships were found between the Standardized Mini Mental Test and the Fugl Meyer Upper Extremity Rating Scale, Frenchay Arm Test and Box-Block Test ($p<0.05$). Between SMMT and 'Flexor synergy' and 'Normal reflex activity', which are sub-titles of Fugl Meyer Upper Extremity Rating Scale a statistically significant correlation was found ($p<0.05$). In addition, between the subtitles of the Stroop Test TBAG form 'Chapter 3 Error' and the subtitles of the Fugl Meyer Upper Extremity Evaluation Scale 'Reflex Activity'; statistically significant relationships were also found between 'Chapter 2 Correction' and 'Reflex activity', 'Extensor synergy' and 'Non-synergy movement'($p<0.05$). No statistically significant correlation was found between the other parts of the Stroop Test TBAG Form and the scales assessing upper extremity functions ($p>0.05$).

Conclusion: The results obtained from this study show that there is a relationship between the cognitive level and upper extremity functions in patients with chronic stroke. More efficiency can be obtained by taking ocnsider these two components as two components that may affect each other in the evaluation stages of patients and may help to create more personalized and successful programs.

Key Words: Chronic Stroke, Cognitive Level, Upper Extremity, Function

ÖZ

Amaç: İnme sonrası kognitif bozukluk ve üst ekstremite fonksiyonlarında kayıplar yaygındır ve bu iki bileşen anatomik ve fonksiyonel bağlamda birbirini etkileyebilmektedir. Bu çalışmada kronik inmeli hastalarda kognitif düzey ile üst ekstremite fonksiyonları arasındaki ilişkinin incelenmesi amaçlandı.

Yöntem: Çalışmaya Pamukkale Üniversitesi Hastanesi'nde değerlendirilen inme tanısı almış, kronik evrede ve yaş ortalaması 61.33±12.71 olan 39 birey dahil edildi. Bireylerin kognitif düzeylerini değerlendirmek için Standardize Mini Mental Test (SMMT) ve Stroop Testi Temel Bilimler Araştırma Grubu (TBAG) Formu kullanıldı. Üst ekstremite fonksiyonlarını değerlendirmek için Fugl Meyer Üst Ekstremite Değerlendirme Ölçeği, Frenchay Kol Testi ve Kutu- Blok Testi kullanıldı.

Bulgular: Çalışmanın bulguları incelendiğinde, Standardize Mini Mental Test ile Fugl Meyer Üst Ekstremite Değerlendirme Ölçeği, Frenchay Kol Testi ve Kutu-Blok Testi arasında istatistiksel olarak anlamlı ilişkiler bulundu ($p<0.05$). SMMT ile Fugl Meyer Üst Ekstremite Değerlendirme Ölçeği'nin alt başlıkları olan "Fleksör Sinerji" ve "Normal Refleks Aktivite" arasında istatistiksel olarak anlamlı bir ilişki bulundu ($p<0.05$). Ayrıca Stroop Testi TBAG formunun alt başlıkları olan "Bölüm 3 Hata" ile Fugl Meyer Üst Ekstremite Değerlendirme Ölçeği'nin alt başlıkları olan "Refleks Aktivite" arasında; "Bölüm 2 Düzeltme" ile "Refleks Aktivite", "Ekstansör Sinerji" ve "Sinerji Dışı Hareket" arasında da istatistiksel olarak anlamlı ilişkiler bulundu ($p<0,05$). Stroop Testi TBAG Formunun diğer bölümleri ile üst ekstremite fonksiyonlarını değerlendiren ölçekler arasında istatistiksel olarak anlamlı bir ilişki bulunmadı ($p>0.05$).

Sonuç: Bu çalışmadan elde edilen sonuçlar kronik inmeli hastalarda kognitif düzey ile üst ekstremite fonksiyonları arasında ilişki olduğunu ve rehabilitasyon sürecinde kognitif terapiler ile üst ekstremite fonksiyonlarını geliştirmeye yönelik tekniklerin birlikte uygulanarak tedaviden daha fazla verim alınabileceğini gösterdi.

Anahtar Kelimeler: Kronik İnme, Kognitif Düzey, Üst Ekstremite, Fonksiyon

Article Info/Makale Bilgisi

Submitted/Yükleme tarihi: 29.11.2023, **Revision requested/Revizyon isteği:** 21.12.2023, **Last revision received/Son düzenleme tarihi:** 06.02.2024, **Accepted/Kabul:** 13.02.2024

*** Corresponding author/Sorumlu yazar:** Ankara Yıldırım Beyazıt University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Ankara, Türkiye
[1*]Email: hilalaslan@aybu.edu.tr, [2]Email: ebaskan@pau.edu.tr

A paper was presented at the 6th International Istanbul Scientific Research Congress, which took place on October 30-31, 2021, with some data obtained from this study.

INTRODUCTION

Stroke, cerebrovascular accident (CVA); it is a serious syndrome that causes damage to a certain region of the brain due to problems in the blood circulation, and clinical findings are seen according to the affected brain region. It may develop due to stroke, ischemia or hemorrhage. Symptoms settle quickly, vary in severity, and can result in death [1,2]. The cause of stroke, the portion supplied by the affected artery in stroke, and the size of this portion affect the clinical findings accompanying the stroke [3]. Loss of balance and coordination, impaired gait, sudden headache of unknown origin are the most common acute clinical findings [4].

Cognitive impairment is common after stroke, and studies have shown that this rate is 35% in the first 3 months and 32% in the next 3 years [5,6]. Depending on the location and severity of the lesion, the severity and type of cognitive impairment may also vary in stroke patients. Loss of patients' memory, attention, concentration, problem solving, thinking and decision-making abilities are frequently encountered problems. It is accepted by some authors that visual-spatial perception and apraxia are among cognitive problems. In order to provide an effective and successful rehabilitation, patients must be able to perceive commands, give the necessary responses and have the capacity to learn. Loss of these abilities will negatively affect the rehabilitation process [6-9].

The most common neurologic involvement after stroke is in upper extremity motor functions, and studies show that upper extremity dysfunction is present in 85% of patients [10]. If stroke severity is severe, only 15% of patients may experience improvement in hand functions [11]. Studies have shown that upper extremity neurologic dysfunction after stroke showed that recovery was in the first 3 months [3].

Studies conducted in recent years show that cognitive and physical areas are closely related [12], but neurorehabilitation focuses more on the motor system and the cognitive aspect of motor movements is put into the background [13]. Attention is very important for perception – cognition ability, and attention losses in stroke patients cause decreases in motor functions. Disturbances in the motor mechanism of the pyramidal system also lead to upper extremity functional losses in stroke patients [14]. Motor dexterity of the hemiparetic upper extremity has been shown to be associated with increased activation of the prefrontal areas involved in working memory and visuospatial transformations [15]. These results suggest that cognitive aspects of motor control are associated with modulation of activity in the common motor cortical area and associated areas [16].

Studies on the rehabilitation process of stroke patients have shown that cognitive processes and arm motor development have a positive relationship and that deficits in memory and executive attention negatively affect upper limb motor recovery of patients [17,18]. Although research in recent years has increasingly focused on the effect of cognitive performance on motor performance [19], many studies on upper extremity rehabilitation after stroke have not considered cognitive skills. The ICF (International Classification of Function) definition, which is the basis for planning rehabilitation processes, considers body structure and functions, activity and participation parameters, and cognitive and motor processes as processes that affect each other [20]. Considering these relationships between upper extremity performance and cognitive skills, it is emphasized that these parameters should not be considered separately in rehabilitation and evaluation processes.

Studies have focused on the effects of cognitive rehabilitation approaches on motor function, and there are few studies on upper extremity functions, more specifically. Our study was planned based on the hypothesis that cognitive processes and upper extremity performance are related in chronic stroke patients. Our aim is to contribute to the literature and to give clinicians an idea about the evaluation process of patients by considering these parameters.

METHOD

Research Design and Population

The population of the study, which was planned as a descriptive and cross-sectional study, consisted of stroke patients evaluated at Pamukkale University Hospital between August 2020 and April 2021. 39 individuals, 12 women and 27 men with a mean age of 61.33±12.71 years who were diagnosed with stroke were included in the study. While the inclusion criteria of the individuals in the study were to be volunteers, to have had an ischemic or hemorrhagic stroke, to be diagnosed with CVA at least six months ago, to have no more than one stroke, to have no communication problems, and to be able to read and write, the exclusion criteria were; having hearing loss, receiving additional treatment for rehabilitation, having an orthopedic disorder, having undergone recent surgery, having additional neurological disease other than stroke, having a psychological disorder, having a previous disease that may affect his cognitive level, and not meeting the inclusion criteria. The inclusion processes of the individuals participating in the study are shown in Figure 1.

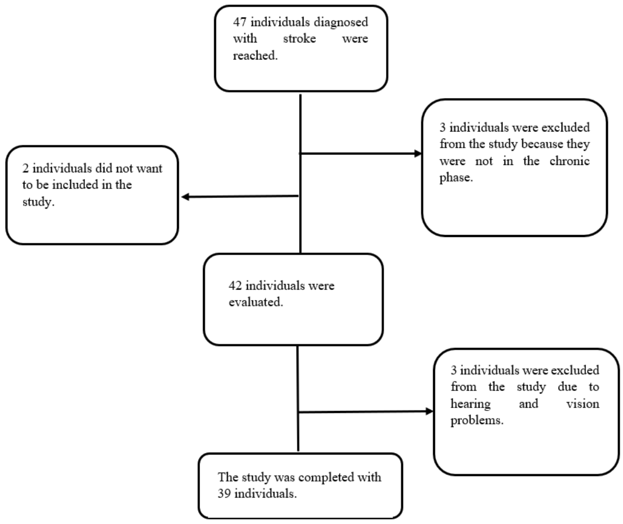

Figure 1. The scheme of selection of individuals to work

Sample Size Calculation

G*Power package software program (G*Power, Version 3.1.9.7, Franz Faul, Universität Kiel, Germany) was used to calculate the required sample size for the study. Considering the upper extremity function parameter in a similar study [21], it was calculated that a sample of 34 people was required to obtain 90% power with an effect size of d=0.20, type I error of α=0.05 and type II error of β=0.10. The sample selection of the study was completed with 39 chronic stroke patients who met the inclusion criteria using simple random sampling method.

In addition to the demographic data of the individuals participating in the research; history of stroke, type of stroke, personal and family history, height and weight, use of assistive devices, smoking, alcohol use, dominant and affected extremities, and existing comorbidities were also recorded. All individuals were evaluated in Pamukkale University Hospital.

Outcome Measures

Cognitive State

The cognitive levels of the individuals participating in the study were evaluated with the Standardized Mini Mental Test and the Stroop Test TBAG Form.

The Standardized Mini-Mental Test (SMMT) created by Folstein et al. in 1975, is a practical and easy-to-apply test for the assessment of cognitive and dementia disorders [22]. The reliability and validity studies of the Turkish form of SMMT were performed by Güngen et al. in 2002. SMMT; It consists of five parts: orientation, recording, attention and calculation, recall and language tests. The total score is 30, those who score 24 points or less are at risk for cognitive impairment [23,24].

The Stroop Test was developed by Stroop in 1935 and is a neuropsychological test that measures focused attention and information processing speed. The test is based on measuring the reader's reaction time in the face of this confounding effect when the color of the written word and the color the word expresses are different [25]. In this study, the Stroop Test TBAG form, adapted to Turkish culture and proven to be valid and reliable, was used, which was developed within the scope of the Stroop Test BİLNOT Battery. Stroop Test TBAG Form is applied with four cards and consists of five parts. Color names printed in black on the 1st card, color names printed in color on the 2nd card (the color in which the word is written on this card and the color the word denotes are different), the circles printed in different colors on the 3rd card, and the neutral words printed in color but without a color name are included on the 4th card. The 2nd card with the color names printed in color is used both in the 2nd part and in the 5th part. In the evaluation, the duration of each section, the number of errors and corrections are recorded [26].

Upper Extremity Functions

Upper extremity functions of the individuals participating in the study were evaluated with Fugl Meyer Upper Extremity Rating Scale, Frenchay Arm Test and Box Block Test (BBT).

The Fugl Meyer Upper Extremity Rating Scale (FMA-UE) is a frequently recommended scale, especially for use in stroke patients, and is based on measuring performance [27, 28]. The test consists of reflex activity, flexor and extensor synergy, combined synergistic movements, non-synergy movements, normal reflex activity, wrist and hand evaluation, coordination and speed evaluation. It consists of 33 items in total and each item is scored between 0 and 2 points (0: unable, 1: partially able, 2: fully able). The total score is 66. It is easy to apply, it does not require much equipment, the items in the house are sufficient and it takes about 30 minutes [29, 30].

The Frenchay Arm Test is based on measuring the functional abilities of the affected upper extremity. The test consists of five simple upper extremity tasks. In case of successful completion of the tasks, 1 point is awarded and the total score is 5. The patient tries to do the following five items using the affected upper extremity:

1- Fixing the ruler

2- Keeping a cylinder

3- Raising the glass

4- Attaching a latch to the bar

5- Combing hair [31].

The application of the Frenchay arm test to individuals is shown in Figure 2.

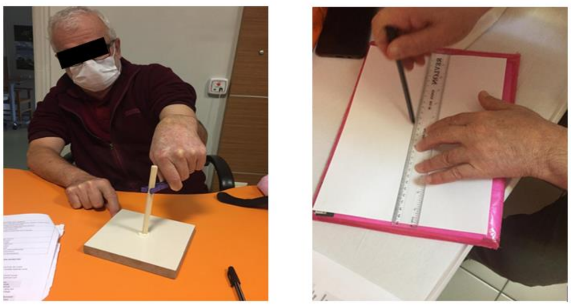

Figure 2. The application of the Frenchay arm test to individuals (Attaching a peg to a stick- Fixing the ruler)

The Box-Block Test was developed to assess rough manual dexterity and is a very simple, practical and quick test to use. For the test, a box and small wooden blocks are used, which is divided into two equal areas right in the middle. Small wooden blocks are all placed on one side of the box. For the test, the patient is told to throw the wooden blocks in one section into the other section as quickly as possible and 60 seconds are given. The test is applied to both the dominant and non-dominant hand and the number of wooden blocks thrown to the opposite side gives the total score. The test is particularly suitable for patients with limited grip and dexterity [32]. The application of the Box- Block test to the individuals is shown in Figure 3.

Figure 3. Application of the Box-Block test to the individuals.

Ethical Approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Pamukkale University Non-Interventional Clinical Research Ethics Committee on 29/07/2020 (No:14). All participants were informed about the study before participating in the study and the necessary written consent was obtained.

Statistical Analysis

Statistical analysis of the data was performed using IBM SPSS version 26. The conformity of the data to the normal distribution was examined using the Shapiro Wilk test, histograms and probability pilots. Normally distributed data were showed as mean- ± standard deviation (SD), non-normal distributions were showed as median (minimum-maximum), and ordinal variables were showed as frequency and percentage. Spearman correlation analysis was used to examine the relationship between the data. $P<0.05$ was accepted for statistical significance. Correlation analysis results were classified as follows: 0.00-0.20 (poor correlation), 0.21-0.40 (fair correlation), 0.41-0.60 (moderate correlation), 0.61-0.80 (good correlation), and 0.81-1.00 (very good correlation) [33].

RESULTS

A total of 39 individuals, 12 women (30.8%) and 27 men (69.2%), with a mean age of 61.33±12.71 years, aged between 43 and 87 who were diagnosed with stroke were included in the study. Demographic data of individuals are shown in Table 1.

Table 1. Demographic data of individuals

Variables	Mean±SD	Median	Minimum-Maximum
Age (years)	61.33±12.71	60	43-87
Length (cm)	166.38±6.62	167	152-180
Body weight (kg)	78.74±13.73	80	52-110
BMI(kg/m²)	28.49±5.13	28.30	18.64-41.91
Disease duration (month)	20.10±2.37	14	7-66

SD:Standart deviation, BMI:Body mass index.

Twenty of the subjects had left extremity involvement, 19 had right extremity involvement, and 32 had ischemic stroke and 7 had hemorrhagic stroke. Other descriptive characteristics of individuals are shown in Table 2.

Table 2. Descriptive characteristics of individuals

Variables		n	%
Gender	Female	12	30.8
	Male	27	69.2
Type of stroke	Ischemic	32	82.1
	Hemorrjahic	7	17.9
Effected side	Right	19	48.7
	Left	20	51.3
Smoking	Yes	18	46.2
	No	21	53.8
Alcohol use	Yes	1	2.6
	No	38	97.4
Use of assistive devices	Yes	24	61.5
	No	15	38.5
Total		39	100

n:Number, %:Percent

According to the Standardized Mini Mental Test, the cognition levels of the cases; 6 of them were severe dementia (15.4%), 9 of them were mild dementia (23.1%), and 24 of them were normal (61.5%). The findings related to the numerical data obtained from the Standardized Mini Mental Test and Stroop Test TBAG Form test results, Fugl Meyer Upper Extremity Assessment Scale total score and sub-headings, Frenchay Arm Test and Box Block tests of the individuals included in the study are shown in Table 3 and Table 4.

Table 3. Findings related to cognition level assessment scales of individuals

Scales	X±SD	Median	Min-Max
SMMT	23.79±5.31	26	11-29
Stroop Part 1- Time (s)	22.56±6.72	23.15	9-37.15
Stroop Part 2- Time (s)	28.27±7.33	26.20	13.10-46.11
Stroop Part 3- Time (s)	29.64±7.81	28.70	13.56-50.77
Stroop Part 4- Time (s)	37.19±7.59	37.40	21.50-52.65
Stroop Part 5- Time (s)	43.23±9.32	43.75	24.70-69.10
Stroop Part 1- Error	0.12±0.65	0	0-4
Stroop Part 2- Error	0.38±1.16	0	0-6
Stroop Part 3- Error	0.48±0.75	0	0-2
Stroop Part 4- Error	0.66±1	0	0-4
Stroop Part 5- Error	0.74±0.96	0	0-3
Stroop Part 1- Correction	0.25±0.63	0	0-3
Stroop Part 2- Correction	0.38±0.74	0	0-3
Stroop Part 3- Correction	0.41±0.67	0	0-2
Stroop Part 4- Correction	0.56±0.82	0	0-3
Stroop Part 5- Correction	1.35±1.01	1	0-4

X:Mean, SD:Standard deviation, Min:minimum; Max:maximum; S:Second

As a result of the correlation analysis, a statistically fair level of significant and positive correlation was found between the Standardized Mini Mental Test (SMMT) and the Fugl Meyer Upper Extremity Rating Scale, Frenchay Arm Test and Box-Block Test (affected extremity) (respectively; r:0.327, p:0.042; r:0.327, p:0.042; r:0.326, p:0.043). In addition, a moderately significant and positive relationship was found between SMMT and Flexor synergy and Normal reflex activity, which are sub-headings of the FMA-UE (r:0.470, p:0.003 and r:0.401, p:0.011, respectively). A statistically fair level of significant and negative correlation was found between the

Table 4. Findings related to the upper extremity rating scales of individuals

Scales	X±SD	Median	Min-Max
Fugl-Meyer Upper Extremity Rating Scale (Total)	40.20±16.78	43	7-66
Reflex activity (FMA-UE)	3.33±1.32	4	0-4
Flexor synergy (FMA-UE)	7.71±2.75	8	1-12
Extensor synergy (FMA-UE)	4.35±1.59	4	1-6
Combined synergistic movements (FMA-UE)	3.71±2.06	4	0-6
Non-synergy movements (FMA-UE)	3.20±1.92	3	0-6
Normal reflex activity (FMA-UE)	0.97±2.15	0	0-6
Wrist assessment (FMA-UE)	5.66±3.60	7	0-10
Hand assessment (FMA-UE)	8.30±4.05	8	0-14
Coordination and speed (FMA-UE)	3.07±1.36	3	1-5
Frenchay Arm Test	3.64±1.67	4	0-5
Box-Block Test (affected upper extremity)	24.94±14.25	26	0-55
Box-Block Test (unaffected upper extremity)	49.28±14.42	49	21-84

FMA-UE:Fugl-Meyer Upper Extremity Rating Scale

Stroop Test Chapter 3 Error section and the reflex activity, which is one of the sub-headings of FMA-UE (r:-0.391, p:0.014). On the other hand, a statistically fair significant and negative correlation was found between the Section 2 Correction section of the Stroop Test and the reflex activity and non-synergy movement sections of the FMA-UE, and a moderately significant and negative relationship between the extensor synergy section (r:-0.384, respectively). p:0.016; r:-0.389, p:0.015; r:-0.564, p<0.001; r:-0.389, p:0.015). There was no significant relationship between the other parts of the Stroop test and the upper extremity rating scales (p>0.05). The findings of the correlation analysis of the data are shown in Table 5.

Table 5. Correlation analysis findings of the data

Variables	Fugl Meyer UERS	Frenchay Arm Test	Box and Block Test (affected)	Box and Block Test (unaffected)
SMMT	r:0.327* p:0.042	r:0.327* p:0.042	r:0.326* p:0.043	r:0.229 p:0.161
Stroop P1-time	r:- 0.220 p:0.179	r:- 0.156 p:0.342	r:- 0.246 p:0.131	r:- 0.036 p:0.827
Stroop P2-time	r:-0.87 p:0.597	r:-0.196 p:0.232	r:-0.187 p:0.255	r:-0.052 p:0.751
Stroop P3-time	r:0.092 p:0.576	r:-0.051 p:0.760	r:-0.177 p:0.280	r:-0.002 p:0.989
Stroop P4-time	r:-0.113 p:0.495	r:-0.190 p:0.246	r:-0.199 p:0.225	r:-0.023 p:0.889
Stroop P5-time	r:-0.008 p:0.962	r:-0.074 p:0.653	r:-0.113 p:0.493	r:-0.155 p:0.346
Stroop P1-error	r:-0.189 p:0.249	r:-0.017 p:0.918	r:-0.096 p:0.560	r:0.102 p:0.536
Stroop P2-error	r:-0.250 p:0.125	r:-0.105 p:0.526	r:-0.274 p:0.091	r:0.006 p:0.973
Stroop P3-error	r:0.009 p:0.956	r:0.078 p:0.636	r:0.115 p:0.485	r:-0.153 p:0.352
Stroop P4-error	r:0.065 p:0.693	r:-0.077 p:0.640	r:0.070 p:0.673	r:0.177 p:0.282
Stroop P5-error	r:0.139 p:0.398	r:0.103 p:0.533	r:0.248 p:0.128	r:0.217 p:0.184
Stroop P1-correction	r:-0.051 p:0.757	r:-0.035 p:0.832	r:0.015 p:0.925	r:0.013 p:0.936
Stroop P2-correction	r:-0.347* p:0.031	r:-0.291 p:0.073	r:-0.278 p:0.087	r:-0.177 p:0.282
Stroop P3-correction	r:0.038 p:0.818	r:-0.180 p:0.274	r:-0.182 p:0.266	r:0.173 p:0.294
Stroop P4-correction	r:0.126 p:0.446	r:0.099 p:0.550	r:0.203 p:0.214	r:-0.028 p:0.865
Stroop P5-correction	r:0.128 p:0.436	r:-0.031 p:0.850	r:0.104 p:0.527	r:-0.123 p:0.456

*SMMT:The Standardized Mini-Mental Test, Strroop P:Stroop Part, r:correlation coefficient, *p<0.05.*

DISCUSSION

In the recent study in which we examined the relationship between cognitive level and upper extremity functions in patients with chronic stroke, we found that there was a relationship between general cognition level and upper extremity functions, but there was a limited relationship between cognitive information processing and attention skills and upper extremity functions. These results support our study hypothesis in general.

Imaging studies examining the relationship between cognition and upper extremity function in stroke patients show that movement-related activity in the premotor and prefrontal cortex is dependent on the cognitive context [34]. Another similar physiologic basis is that the area occupied by the upper extremity in the motor and sensory homunculus is greater than the lower extremity. Especially in middle cerebral artery injuries, since this artery perfuses the areas corresponding to the upper extremity and face regions in the homunculi, the effect will be greater in these areas. Therefore, any damage to the cortex will affect upper extremity functions more [35].

In a study that evaluated upper extremity functions with the Box-Block Test in acute stroke patients, similar to our study, and examined its relationship with cognition, it was shown that cognitive performance is effective on arm motor skills [36]. Similar to our study, Roh et al. examined the relationship between cognition and upper extremity performance in chronic stroke patients and the effects of these parameters on activities of daily living. Their results showed that the two parameters were related to each other and to the performance in daily living activities [37].

The results of the recent study support our hypothesis based on this neurophysiological basis and show that there is a relationship between general cognitive level and upper extremity functions.

There are four studies examining the relationship between the affected extremity and cognitive functions in stroke patients, and these studies found correlations between both attention and visuospatial functions and extremity functions [38- 41]. The relationship between sustained attention and affected upper extremity functions has also been demonstrated in patients with right hemisphere involvement, especially two years after stroke [39]. In addition, an association was found between affected hand motor skills and basic attention and reasoning in the acute period [38]. Levin et al. showed that executive function performance has a more significant effect on upper extremity function than other cognitive abilities in stroke patients [42]. In another study, this was attributed to the fact that executive functions play a major role in the body's ability to make the necessary adjustments to changing environmental conditions as a result of functional movements [43]. In this recent study, we found associations between information processing speed and selective attention abilities and upper extremity parameters in patients with chronic stroke that are difficult to generalize. The reasons for this result can be varied. To assess executive functions and selective attention, we used the Stroop Test, a cognitive test consisting of different colors and words in which abilities are assessed in units of duration, error and correction. The test is a commonly used test to assess selective attention and executive functions in stroke patients and in upper extremity injuries in order to examine the effect of cognitive performance on motor performance [44,45]. We included stroke patients with a wide age range and varying levels of visual and reading skills, which may have affected their performance on the Stroop Test. The SMMT, another test we use to assess cognitive level, is one of the most well-known tests for the assessment of general cognitive level, memory and dementive disorders. Our findings showed that there were significant correlations between all parameters evaluating the upper extremity and SMMT. This may be attributed to both the physiological basis of our study and the way the test was adapted. The majority of the SMMT was administered in a question and answer format between the assessor and the patient, which facilitates the completion of the test for the patient. Although findings of the recent study support similar studies in the literature, there is a need to find stronger associations using different measures specific to these abilities in order to make stronger interpretations.

Recovery in upper extremity functions after stroke is more difficult compared to lower extremity. This is due to the fact that upper extremity functions are more complex. From a functional point of view, upper extremity especially hand functions involve difficult fine motor skills such as manipulation, grasping and holding; lower extremity functions include skills such as keeping the body in balance and in an upright position and walking [11,46]. Upper extremity movements require more cognitive components as they require more attention, concentration and a more goal-oriented approach compared to lower extremity movements. Therefore, losses at the level of cognition affect upper extremity functions more. In our study, we used three different tests to evaluate upper extremity functions. There are many studies using these tests in stroke patients [47-49]. The Fugl Meyer Upper Extremity Assessment Scale is a comprehensive scale that considers upper extremity functions in the context of symptoms, similar to a neurological examination. The Frenchay Arm Test evaluates upper extremity functions based on functional skills in daily life. Box-Block Test is an easily applicable and understandable test that evaluates gross motor skills of the hand. In the design of the study, it was aimed to comprehensively evaluate upper extremity functions by using these three tests. One of the aspects that makes our study different from the relevant literature is that it provides a more holistic view of upper extremity functions by using different tests that evaluate more than one function, rather than a single test.

Limitations

Our study has some limitations. The first of these was that the age range of the patients included in the study was wide and therefore their various physical abilities showed a wide range of variation. This caused the results of the tests to be very variable. Another limitation was that it was not taken into account that whether the patients were right or left dominant could affect their cognitive and arm skills.

The literature focuses on the contribution of using various cognitive strategies during the treatment process to the development of upper extremity function rather than the evaluation phase. We think that the results of recent study will be beneficial especially in terms of giving clinicians a preliminary idea about the patients in the evaluation process, providing a more individualized treatment program for patients, and using more accurate techniques during rehabilitation.

CONCLUSION

The results of recent study show that there is a significant relationship between general cognitive level and upper extremity function in patients with chronic stroke.

Clinicians and researchers may consider these two components as two components that may affect each other in the evaluation stages of patients and may help to create more personalized and successful programs. Planning rehabilitation programs by taking cognition and upper extremity performance into consideration can make the process more goal oriented and effective in terms of intervention-time interaction.

Ethical Approval: *2020/14 Non-Interventional Clinical Research Ethics Committee of Pamukkale University*

Conflict of Interest: *The authors have no conflicts of interest to declare.*

Funding: *None.*

Acknowledgements: *None.*

Author Contribution: Concept: *HA,EB;* ***Design:*** *HA,EB;* ***Data collecting:*** *HA,EB;* ***Statistical analysis:*** *HA,EB;* ***Literature review:*** *HA;* ***Writing:*** *HA;* ***Critical review:*** *HA,EB.*

REFERENCES

1. Sudlow CL, Warlow CP. Comparing stroke incidence worldwide: what makes studies comparable? Stroke. 1996;27:550-558.
2. Truelsen T, Mahonen M, Tolonen H, Asplund K, Bonita R, Vanuzzo D. Trends in stroke and coronary heart disease in the WHO Monica Project. Stroke. 2003;34(6):1346-1352.
3. Otman AS, Karaduman A, Livanelioğlu A. Cerebrovascular accident. Neurophysiological approaches in hemiplegia rehabilitation. Ankara; HU School of Physical Therapy and Rehabilitation Publications. 2001;1-15.
4. Harvey RL, Macko RF, Stein J, Winstein CJ, Zorowitz RD. Stroke Recovery and Rehabilitation. New York; Demos Medical Publishing. 2008.
5. Haring HP. Cognitive impairment after stroke. Curr Opin Neurol. 2002;15(1):79-84.
6. Hoffmann T, Bennett S, Koh, CL, McKenna K. A systematic review of cognitive interventions to improve functional ability in people who have cognitive impairment following stroke. Top Stroke Rehabil. 2010;17(2):99-107.
7. Quintana LA. Evaluation of Perception and Cognition. In: Trombly CA (ed). Occupational Therapy for Physical Dysfunction, 4rd edn. Baltimore; Williams& Wilkins; 1977;201-223.
8. Reed KL. Cognitive-Perceptual Disorders. In: Zukas RR (ed). Quick Reference to Occupational Therapy. 2rd edn. Texas; Proed; 2001;689-758.
9. Cumming TB, Marshall RS, Lazar RM. Stroke, cognitive deficits, and rehabilitation: still an incomplete picture. Int J Stroke. 2013;8:38-45.
10. Parker VM, Wade DT, Langton-Hewer R. Loss of arm function after stroke: measurement, frequency, and recovery. Int Rehabil Med. 1986;8:69-73.
11. Higgins J, Mayo NE, Desrosiers J, Salbach NM, Ahmed S. Upper-limb function and recovery in the acute phase poststroke. J Rehabil Res Dev. 2005;42:65-76.
12. Haywood K, Getchell N. Life span motor development, 6rd edn. Human Kinetics, Champaign; 2014.
13. Mulder T. A process-oriented model of human motor behavior: toward a theory-based rehabilitation approach. Phys Ther. 1991;71:157-164.
14. Platz T, Bock S, Prass K. Reduced skilfulness of arm motor behaviour among motor stroke patients with good clinical recovery: does it indicate reduced automaticity? Can it be improved by unilateral or bilateral training? A kinematic motion analysis study. Neuropsychologia. 2001;39:687-698.
15. Meehan, SK, Randhawa B, Wessel B, Boyd LA. Implicit sequencespecific motor learning after subcortical stroke is associated with increased prefrontal brain activations: an fMRI study. Hum Brain Mapp. 2011;290-303.
16. Dennis A, Bosnell R, Dawes H et al. Cognitive context determines premotor and prefrontal brain activity during hand movement in patients after stroke. Stroke. 2011;42(4):1056-1061.
17. Mullick AA, Subramanian SK, Levin MF. Emerging evidence of the association between cognitive deficits and arm motor recovery after stroke: a meta-analysis. Restor Neurol Neurosci. 2015;33:389-403.
18. Alt Murphy M, Baniña MC, Levin MF. Perceptuo-motor planning during functional reaching after stroke. Exp Brain Res. 2017;235:3295-3306.
19. Cirstea MC, Levin MF. Improvement of arm movement patterns and endpoint control depends on type of feedback during practice in stroke survivors. Neurorehabil Neural Repair. 2007;21(5):398-411.
20. Barker-Collo S, Feigin V. The impact of neuropsychological deficits on functional stroke outcomes. Neuropsychol Rev. 2006;16(2):53-64.
21. Fong Kenneth NK, Chan Chetwyn CH, AU Derrick KS. Relationship of motor and cognitive abilities to functional performance in stroke rehabilitation. Brain Injury. 2001;15(5):443-453.
22. Herndon R. Handbook of Neurologic Rating Scales. New York; Demos Vermande; 1997.
23. Güngen C, Ertan T, Eker E Yaşar R, Engin F. Validity and Reliability of the Standardized Mini Mental Test in the Diagnosis of Mild Dementia in Turkish Population. Turkish Journal of Psychiatry. 2002;273-282.
24. Folstein MF, Folstein SE, McHugh PR. 'Mini Mental State'. A practical method for granding the cognitive state of patients for the clinician. J Psychiatr Res. 1975;12:189-198.
25. MacLeod CM. Half a century of research on the Stroop effect: an integrative review. Psychol Bull. 1991;109(2):163-203.
26. Karakaş S, Erdoğan E, Sak L et al. Stroop Test TBAG Form: Standardization Studies for Turkish Culture, Reliability and Validity. Clinical Psychiatry. 1999;2:75-88.
27. Gladstone DJ, Danells CJ, Black SE. The fugl-meyer assessment of motor recovery after stroke: a critical review of its measurement properties. Neurorehabil Neural Repair. 2002;16:232-240.
28. Van Wijck FM, Pandyan AD, Johnson GR, Barnes MP. Assessing motor deficits in neurological rehabilitation: patterns of instrument usage. Neurorehabil Neural Repair. 2001;15:23-30.
29. Deakin A, Hill H, Pomeroy VM. Rough Guide to the Fugl-Meyer Assessment: Upper limb section. Physiotherapy. 2003;89:751-763.
30. Sullivan KJ, Tilson JK, Cen SY et al. Fugl-Meyer assessment of sensorimotor function after stroke: standardized training procedure for clinical practice and clinical trials. Stroke. 2011;42:427-432.
31. Soyuer F. Examination of upper extremity functions in hemiplegic patients [Master's thesis]. Ankara: Hacettepe University Institute of Health Sciences. 2000;20.
32. Mathiowetz V, Volland G, Kashman N, Weber K. Adult norms for the box and block test of manual dexterity. Am J Occup Ther Jun. 1985;39:386-391.
33. Altman DG. Practical statistics for medical research. London; Chapman and Hall. 2013.
34. Schluter ND, Krams M, Rushworth MF, Passingham RE . Cerebral dominance for action in the human brain: The selection of actions. Neuropsychologia. 2001;39:105.
35. Nguyen JD, Duong H. Neurosurgery, Sensory Homunculus. Florida; StatPearls Publishing; 2021.
36. Lin DJ, Erler KS, Snider SB, et al. Cognitive demands influence upper extremity motor performance during recovery from acute stroke. Neurology. 2021;96(21):e2576-e2586.
37. Roh HL, Kim CW. Cognition and upper-extremity function influence on performance of activities of daily living in patients with chronic stroke. J Korean Soc Phys Med. 2019;14(4):115-123.
38. Hyndman D, Pickering RM, Ashburn A. The influence of attention deficits on functional recovery post stroke during the first 12 months after discharge from hospital. J Neurol Neurosurg Psychiatry. 2008;79:656-663.
39. Robertson IH, Ridgeway V, Greenfield E, Parr A. Motor recovery after stroke depends on intact sustained attention: a 2-year followup study. Neuropsychology. 1997;11:290-295.
40. Sveen U, Bautz-Holter E, Sodring KM, Bruun WT, Laake K. Association between impairments, selfcare ability and social activities 1 year after stroke. Disabil Rehabil. 1999;21:372-327.
41. Sunderland A, Bowers MP, Sluman SM, Wilcock DJ, Ardron ME. Impaired dexterity of the ipsilateral hand after stroke and the relationship to cognitive deficit. Stroke. 1999;30:949-955.
42. Levin MF, Subramanian SK, Chilingaryan G, Sveistrup H. Influence of depression and cognitive deficits on use of feedback for upper limb recovery in chronic stroke. Neurorehabil Neural Repair. 2014;28(9):924.
43. Elliott R. Executive functions and their disorders. Br Med Bull. 2003;65(1):49-59.
44. Saverino A, Waller D, Rantell K, Parry R, Moriarty A, Playford ED. The role of cognitive factors in predicting balance and fall risk in a neuro-rehabilitation setting. PLoS One. 2016;11:e0153469.
45. Zhang X, Tse T, Li T, Zoghi M. Is there an association between traumatic peripheral lesions and cognitive impairments in adults? A scoping review. Adv Rehabil. 2023;37(1):1-11.
46. Desrosiers J, Malouin F, Richards C, Bourbonnais D, Rochette A, Bravo G. Comparison of changes in upper and lower extremity impairments and disabilities after stroke. Int J Rehabil Res. 2003;26:109-116.
47. Arciniegas DB, Kellermeyer GF, Bonifer NM, Anderson-Salvi KM, Anderson CA. Screening for cognitive decline following single known stroke using the Mini-Mental State Examination. Neuropsychiatr Dis Treat. 2011;189-196.
48. Timmermans AA, Verbunt JA, van Woerden R, Moennekens M, Pernot DH, Seelen HA. Effect of mental practice on the improvement of function and daily activity performance of the upper extremity in patients with subacute stroke: a randomized clinical trial. J Am Med Dir Assoc. 2013;14(3):204-212.
49. Lin DJ, Erler KS, Snider SB. Cognitive demands influence upper extremity motor performance during recovery from acute stroke. Neurology. 2021;96(21):e2576-e2586.