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Original Study

Does Upper Extremity Proprioceptive Training Have an Impact on Functional Outcomes in Chronic Stroke Patients?

Kronik İnme Hastalarında Üst Ekstremite Proprioseptif Eğitimin Fonksiyonel Sonuçlara Etkisi Var mıdır?

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ABSTRACT

Objective: *We aimed to investigate the effect of upper extremity proprioceptive training on spasticity and functional motor skills in patients with chronic hemiplegia occurring after stroke.*
Method: *Thirty chronic hemiplegic patients (17 females, mean age: 66.47±12.55 years) admitted to the Research Center with a diagnosis of chronic hemiplegia developed after stroke were included in the study. Patients were divided into two groups. The first group received a conventional physiotherapy program (PTR) for 5 days a week and the second group additionally received a proprioceptive training program (PTR-PT) for 5 days a week. Before and 6 weeks after the treatment modified Ashworth scale (MAS), Fugl-Meyer upper extremity motor evaluation scale (FMA) and action-research-arm-test (ARAT) and motor activity log-28 scale (MAL-28) were applied. SSPS-22.0 program was used for statistical evaluation and p <0.05 was considered as the level of statistical significance*
Results: *There was no difference in MAS scores before and after treatment in the groups (p>0.05). There was a statistically significant improvement in both PTR (p<0.05) and PTR-PT groups (p<0.001) for the FMA, ARAT and MAL-28. scale scores. Although the results obtained in the PTR, and PT groups were more improved, there was a significant result in favor of PTR-PT only regarding the MAL-28 scale scores (p<0.05). It was determined that adding proprioception-based exercises had the greatest effect on FMA, ARAT and MAL-28 in the evaluation of the effect size (>0.3).*
Conclusion: *It was observed that upper extremity proprioceptive training yielded better results in patients with chronic hemiplegia developed after stroke than conventional therapy in increasing the frequency and quality of movement in upper extremity. This result shows that proprioceptive training programs should be added to stroke rehabilitation methods.*

Keywords: *Hemiplegia, proprioceptive training, upper extremity, functionality, rehabilitation*

ÖZ

Amaç: *İnme sonrası, kronik hemipleji olan hastalarda üst ekstremite proprioseptif eğitimin spastisite, fonksiyonel motor beceriler ve günlük yaşam aktivitesi üzerine etkisini araştırmak amaçlanmıştır.*
Yöntem: *Araştırma Merkezine inme sonrası, kronik hemipleji tanısı ile başvuran 30 kronik hemiplejik birey (17 kadın, 66.47±12,55 yaş) çalışmaya dahil edildi. Hastalar iki guba ayrıldı. Birinci gruba haftada 5 gün konvansiyonel fizyoterapi programı (FTR), ikinci gruba ise bu programa ek olarak haftada 5 gün proprioseptif eğitim programı (PE) eklenmiştir. Hastaların tedavi öncesi ve 6 hafta sonrasında; modifiye ashworth ölçeği (MAÖ), Fugl-Meyer Üst Ekstremite Motor Değerlendirme Ölçeği (FÜM), Action-Research-Arm-Testi (ARAT), Motor Aktivite Günlüğü-28 Ölçeği (MAG-28) uygulandı. İstatiksel olarak SSPS-22,0 programı kulanıldı ve p<0,05 anlamlı kabul edildi.*
Bulgular: *Hastaların grup içinde tedavi öncesi ve sonrası değerlerinde MAÖ üzerine bir fark görülmezken (p>0,05), FÜM, ARAT ve MAG-28 ölçeklerinde istatiksel olarak hem FTR (p<0,05) hem de FTR-PE grubunda (p<0,001) iyileşme yönünde anlamlılık vardı. Gruplar arasında FTR ve PE grubunun sonuçları; FTR grubuna göre daha iyi çıkmasına rağmen, sadece MAG-28 ölçeğinde FTR ve PE lehine anlamlı sonuç vardı (p<0,05). Etki büyüklüğünün değerlendirilmesinde, propriyosepsiyonu temel alan egzersizlerin tedaviye eklenmesinin FMA, ARAT ve MAL-28 üzerinde en büyük etkiye sahip olduğu belirlenmiştir (> 0.3).*
Sonuç: *İnme sonrası, kronik hemipleji olan hastalarda üst ekstremite proprioseptif eğitiminin üst ekstremitede hareket sıklığı ve kalitesini artırmada konvansiyonel tedaviye göre daha iyi sonuç gösterdiği görülmüştür. Bu sonuç inme rehabilitasyon yöntemlerine proprioseptif eğitim programlarının da eklenmesi gerektirdiğini bize göstermektedir.*

Anahtar kelimeler: *Hemipleji, proprioseptif eğitim, üst ekstremite, fonksiyonellik, rehabilitasyon*

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INTRODUCTION

Stroke is a disease of the central nervous system (CNS), which is caused by cerebrovascular disorders such as infarction and hemorrhage[1-3]. More than 69% of cerebrovascular lesions cause disturbance of motor function in the upper extremity; therefore, rehabilitation is important[4]. The purpose of rehabilitation in the hemiplegic upper extremity is to prevent complications and to recover lost sensory-motor control[5]. The process of functional motor healing in the upper extremity occurs through neural mechanisms that facilitate spontaneous cortical reorganization. However, evidence suggests that intense stimulation is necessary for better motor improvement[6,7]. Because of this, conventional treatment methods (e.g., strengthening exercises with normal range of joint motion, mobilization techniques and compensatory techniques)[8] are often inadequate in the organization of the upper extremity motor functions[9].

Patients with disturbance of motor function have also been shown to have additional proprioceptive deficits in the incidence rates ranging from 28 to 44%[10]. Since stationary proprioception is essential for the control and realization of movements, understanding the role of proprioception in the post-stroke healing process is important. Proprioception is the capacity of the CNS to determine the situation of all body parts at any moment (static/dynamic). Proprioceptors located at soft tissues can sense the changes and transfer afferent information to the brain[11]. This sensory information originates from muscle spindles as well as Golgi tendon organs, joints, and cutaneous receptors[10]. Stroke patients with proprioceptive deficit have been shown to have less adequate functional outcomes[12,13]. Proprioception has been reported to be an important determinant of gaining independency in basic daily activities during hospital stay[14,15]. Healing of affected motor function in the upper extremity has shown a negative correlation with proprioceptive deficits and positive correlation with baseline motor skill and cognitive state[16,17]. Although presence of proprioceptive deficit at the start of rehabilitation has not been found to be associated with motor or functional healing in the upper extremity within the first 6 post-stroke weeks, its presence has been found to influence outcomes regarding the use of upper extremity for daily activities at the end of the first year[18]. For these reasons, proprioception-based exercises have recently gained increasing importance. Proprioceptive training aims to promote the development of voluntary movement. It is based on the principles of motor learning such as repetition of tasks with simultaneous use of feedback. In the hemiplegic extremity, manipulations that are supported by a physiotherapist aim to re-train the situational/positional/motional awareness consistent with each movement phase[10,11]. The bilateral treatment method, that might be effective on the proprioception of hemiplegic upper extremity, requires situational awareness of both upper extremities[11]. There is a limited number of studies related to the effect of upper extremity proprioceptive training in stroke patients[10,11,19]. Therefore, more studies are needed on this subject. In the present study, we aimed to investigate the effect of upper extremity proprioceptive training that is performed as an adjunct to the conventional treatment on spasticity, functional motor skills, and activities in patients with chronic stroke.

MATERIALS and METHODS

Study Protocol and Patients

This study has a randomized, controlled, and prospective design. The study was approved by Non-interventional Ethics Committee of Uskudar University (26 April 2019-/2019-239). Patients aged 50-75 years who were presented to Physiotherapy Rehabilitation Application and Research Center of Uskudar University (ÜSFİZYOTEM) between April 2019 and January 2020 and with a stroke happened at least 6 months previously were enrolled in the study (n=30). The study was approved by the institution, verbal and written consents were obtained from patients in conformity with the Helsinki Declaration. Patients diagnosed with stroke according to the World Health Organization criteria; presenting with stable overall condition, unilateral hemiplegia and upper extremity Brunnström score of at least 3 points, and adequate cognitive functioning (location-time perception, reading/writing, and cooperation state) were invited to the study. The exclusion criteria of the study were bilateral hemiplegia; unstable overall health condition; presence of major neurological or rheumatological disease affecting musculoskeletal system other than stroke; presence of serious heart disease and chronic systemic disease; and inadequate cognitive functioning.

Using GPower V.3.1.7 (University of Kiel, Kiel, Germany) software, a sample size of 24 patients was determined to achieve 95% confidence limit and 95% power ratio with 0.05 margin of error[10]. Presuming possible dropouts, the total number of patients was determined as 30. Thirty patients were randomized to two groups using block randomization method with the help of Random Allocation Software as follows:

i. Conventional treatment group (PTR; n=15)

ii. Conventional treatment and proprioceptive training group (PTR-PT; n=15)

Rehabilitation Groups

In the conventional treatment group, patients received a rehabilitation program[8] including passive/active/active assistive joint normal range of motion (ROM) exercises based on upper extremity ROM of the patient. In particular, strengthening exercises targeted at anti-spastic muscles, and recommended compensation methods were used in order to prevent the development of complications. Each session of this program lasted 45 minutes. Following the rehabilitation program, electrical stimulation was applied for 15 minutes. Electrical stimulation was applied specifically to the triceps muscles and wrist extensors using a GLOBUS PREMIUM 400 device. A strengthening program was applied to the anti-spastic muscles for 15 minutes using electrical stimulation (70-100 Hz, 150 μs, 6 seconds contraction alternating with 10 seconds relaxation). This program was employed for 5 days a week during a course of 6 weeks.

In the conventional treatment and proprioceptive training group, a proprioceptive training program that lasted for an average of 15-20 minutes was applied in addition to the conventional treatment and electrical stimulation program. This training was determined in consideration of the stages reported by Stone et al.[20] in their review of upper extremity proprioceptive training. A rhythmic stabilization method was one of these stages. In this method, a physiotherapist asked the patient to make an isometric contraction after placing the upper extremity in the appropriate joint ROM. The physiotherapist placed his/her hands at a suitable position on the extremity to give an adequate level of resistance. This was done in order to make the patient react; however, the resistance was not strong enough to break the isometric contraction. Then the duration of rhythmic stabilization and the resistance applied by the physiotherapist increased, while the area of contact between his/her hands and patient's upper extremity was reduced.

In the second stage, patients were first requested to imitate the healthy upper extremity (eyes open/eyes closed) with varying number of positions between 5 and 10, and with from 10 to 20 repeats. The healthy upper extremity was moved passively in the existing ROM into various positions. Patients were requested to repeat this position with their hemiplegic upper extremity first with their eyes open and then closed. When a patient missed the position, he/she was requested to open his/her eyes and imitate the desired position actively again. Between each movement, the arm was brought back to the resting position, and the new appropriate ROM was selected. In the third stage, the hemiplegic upper extremity was passively moved to a position within the joint

ROM and brought back to resting position. Then, the patient was requested to actively imitate the shown movement with eyes first open and then closed. When the patient missed the position, he/she was requested to open eyes and actively repeat the desired position again. Exercises were performed with 5-10 positions and 10-20 repeats a day[20]. The exercises were applied five times a week in the course of 6 weeks. Exercises of these three stages were applied to patients according to the severity of their clinical states.

Evaluations

Patients were evaluated before and after treatment using the assessment methods described below.

• Modified Ashworth Scale (MAS)

MAS was developed by Bohannon and Smith in 1987[21] to measure muscle tonus. It is among the most commonly used scales for clinical and research purposes. The resistance against passive movement is evaluated on a scale of 4 points.

In the current study, biceps muscle was assessed with MAS. The test was performed while patients were positioned supine. While the forearm was held close to the wrist, the patient's elbow was moved passively from maximum possible flexion to maximum extension rapidly within approximately one second. The forearm was in the neutral and supination position. The muscle spasticity was scored by the same physiotherapist as described above.

• Fugl-Meyer Upper Extremity Motor Assessment Scale (FMA)

In the present study, coarse and fine motor functions in upper extremities of patients were assessed with FMA. FMA is a disease-specific, objective scale used for assessment of motor disturbance that was specifically designed to evaluate improvement in motor functions in post-stroke hemiplegic patients. It consists of subcategories assessing joint movement, coordination and reflex activities in shoulder, elbow, forearm, wrist and hand. The maximum available score is 66. The scale was applied to the affected upper extremities of patients in the sitting position. Joint movement was scored as follows: 0 = no movement possible; 1 = partial movement possible; and 2 = normal range of movement. Reflex activities were assessed using a reflex hammer and scored as follows: 0 = no reflex activity, and 2 = reflex activity can be triggered. For assessment of coordination and speed, a finger-to-nose test was repeated five times, and the speed (0 = completed before two seconds; 1 = completed between two to five seconds; and 2 = cannot be completed before six seconds), tremor (0 = marked tremor; 1 = mild tremor; and 2 = no tremor), and dysmetria (0 = marked dysmetria; 1 = mild dysmetria; and 2 = no dysmetria) were evaluated during the test[22].

• Action Research Arm Test (ARAT)

ARAT was developed to assess upper extremity motor functions in hemiplegic individuals, and it has 4 subcategories to assess coarse grasping, fine grasping, holding with fingertip, and coarse movement. It consists of 19 items in total. This test was applied to the affected upper extremity of the patients. The assessment was performed on a table while patients were seated in a chair. Before applying each item, the individual was verbally and visually informed about how the activity should be made. For each item, scoring was made as follows: 0 = no movement; 1 = can partially complete the movement; 2 = can do the movement with difficulty and within abnormally longer duration; and 3 = can do the movement normally. The maximum available score from the 19 items was 57. The higher total score means better motor function in the arm[23].

• Motor Activity Log-28 (MAL-28)

Daily use of the affected upper extremity was assessed using MAL-28. It is a self-statement questionnaire to determine the frequency and quality of movement in the upper extremity. It questions the extent and quality of the individual's use of upper extremity for 14 daily activities including holding a glass or a book. MAL assesses the affected upper extremity not only regarding its functional capability but also its actual use in real life. It assesses the frequency of an individual's use of an affected upper extremity for each daily activity (e.g., switching on the lights, opening a door, etc.)[24].

Statistical Analyses

Statistical analyses were performed with SPSS 22.0 software. Percentage and mean calculations, chi-square test (for categorical data), independent sample t test, Mann Whitney U test, and Wilcoxon test were employed for analysis of the data. In all statistical analyses, normality assumption was examined by Shapiro-Wilk Normality Test. In order to evaluate the significance of the change before and after the treatment, the intragroup effect size (ES) statistics was computed. An effect size (Cohen's d) was calculated as the difference in means divided by the pooled variance for the group (95% confidence intervals). The effect size (ES) was interpreted as defined by Cohen: ≤0.20 : a small effect, 0.20 to 0.50 : moderate effect, 0.50 - 0.80 : a large effect and ≥0.80 : a huge large effect[25]. For all analyses, a p-value of <0.05 was accepted as statistically significant.

RESULTS

There was no dropouts from the study; and of all patients, 17 were female (56.7%) and 13 were male (43.3%). The mean age of patients was 66.47±12.55 years (mean±standard error). Table 1 shows sociodemographic properties of the groups. Since there was no statistically significant difference regarding baseline states, the groups had a homogenous distribution (p>0.05, Table 1).

Table 1. Socio-demographic characteristics according to the groups.

	PTR	PTR-PT	p
Age	67.0±13.8	65.9±12.3	0.82
Gender			
Female	10 (66.7%)	7 (46.7%)	
Male	5 (33.3%)	8 (53.3%)	0.27
Hemiplegic side			
Right	8 (53.3%)	6 (40.0%)	
Left	7 (46.7%)	9 (60.0%)	
Dominant hemisphere involvement	5 (33.3%)	4 (14.4%)	0.46
Non-dominant hemisphere involvement	10 (66.7%)	11(86.60 %)	0.69

PTR, Conventional treatment group; PTR-PT, Conventional treatment and proprioceptive training group, mean±standard error.

Spasticity was evaluated both before and after treatment. Accordingly, there was no statistically significant improvement in intragroup evaluations of the PTR (p= 0.97) and the PTR-PT (p=0.27) groups, respectively. Regarding intragroup evaluations of FMA and ARAT tests, there were statistically significant improvement in both the PTR (p=0.046 vs p=0.049) and the PTR-PT (p=0.001 vs p=0.001) groups, respectively. MAL-28 evaluations performed before and after treatment showed a statistically significant improvement both in the PTR (p=0.049) and the PTR-PT (p=0.001) groups. The mean and standard error values of each group are shown in Table 2 with corresponding analysis of significance.

There was no difference between the two groups regarding evaluation of spasticity (p=0.60). While the PTR-PT group had higher mean scores on FMA and ARAT tests, there was no statistically significant difference between the groups (p=0.32 and p=0.19, respectively) (Table 2). Comparison of MAL-28 scores, that assess the frequency and quality of movement, showed a significant difference between the groups that was in favor of the PTR-PT group (p=0.002, Table 2).

The mean FMA score increased by 1.07 points (ES=0.07) for the patients' in the PTR group, and 6.66 points (ES=0.73) for the patients' in the PTR-PT group. The mean ARAT and MAL-28 scores increased by 0.93 and 0.06 points (ES=0.05 and 0.06, respectively) for the patients' in the PTR group, and 5.13 and 0,64 points (ES=0.46 and 0.33, respectively) for the patients' in the PTR-PT group (Table 2).

Table 2. Evaluation of spasticity, motor function, and activity within and between groups.

Evaluations		Before treatment	After treatment	intra-group evaluations (p)	Effect size	Inter-group evaluation (p)
MAS		1.86±1.45	1.86±1.47	0.97	0	0.60
	PTR	2.13±1.54	2.46±1.88	0.28	0.21	
	PTR-PT					
FMA		34.86±14.39	35.93±15.00	0.046*	0.07	0.32
	PTR	34.20±9.07	40.86±11.26	0.001***	0.73	
	PTR-PT					
ARAT		29.40±16.45	30.33±16.91	0.049*	0.05	0.19
	PTR	34.40±10.98	39.53±12.55	0.001***	0.46	
	PTR-PT					
MAL-28		1.43±0.96	1.49±1.03	0.043*	0.06	0.002**
	PTR	2.36±1.03	2.70±0.98	0.001***	0.33	
	PTR-PT					

*PTR, Conventional treatment group; PTR-PT, Conventional treatment and proprioceptive training group; MAS, Modified Ashworth Scale; FMA, Fugl-Meyer Upper Extremity Motor Assessment Scale; ARAT, Action Research Arm Test; MAL-28, Motor Activity Log-28; mean±standard error. *p<0.05; **p<0.01; ***p<0,001; The effect size was 0.20 or less is a small effect, 0.20 to 0.50 is a moderate effect, and 0.80 or greater is a large effect.*

DISCUSSION

The present study was conducted to investigate the effect of upper extremity proprioceptive training in patients with post-stroke chronic hemiplegia on spasticity, functional motor skills, and activities. Results of the study pointed out that while there was no difference between the pre-and post- treatment values within groups with regard to spasticity, scores from both upper extremity functional motor assessment scales and MAL-28 scores showed significant improvement in both groups. In comparison of the two groups, only MAL-28 scores showed trhe presence of a significant difference that was in favor of the PTR-PT group, although the PTR-PT group had better results. These large effect sizes might suggest that proprioceptive trainings were effective for the improvement in functional motor skills, and activities in patients with stroke.

In a pilot study, Kiper et al.[11] suggested that spasticity can be significantly improved by proprioceptive training in patients with upper limb paralysis after subacute stroke (3-6 months), but they could not demonstrate its benefit in terms of spasticity and motor function. However, in this study, we observed improved motor function in both groups but not a reduction in spasticity in neither of the conventional nor the proprioceptive training groups. We believe this is because we included chronic stroke patients (>6 months) in the study. In addition, the lack of increase in the modified Ashworth scale scores suggests that the conventional treatment and the proprioceptive training did not cause an increase in pathological muscle tone, hence they did not have unfavorable effects.

One aim of stroke rehabilitation is to have the individuals achieve maximum independence in their daily living activities. However, commonly used conventional treatment methods do not give enough importance to the proprioceptive treatment and often fail in rrecovery of upper extremity motor functions[9,26,27]. Rand et al.[19] reported that motor and proprioceptive deficits lead to poor functional outcomes in stroke patients. A 2018 study with 102 chronic stroke patients (71 patients with proprioceptive deficit and 31 patients with mild-moderate loss) showed moderately significant negative correlations between evaluations based on FMA, ARAT, and MAL-28 scale scores[10]. For these reasons, proprioceptive exercises have gained importance in recent years.

In their pilot study with subacute stroke patients (6 patients), Kiper et al.[11] reported that they could not find any improvement in the FMA scores of a three-week proprioception-based course. However, in our study, we observed significant improvements in the scores of both functional motor assessment (FMA and ARAT), and also MAL-28 scales. The reason for this difference might be that we had a greater number of patients, and the treatment period was relatively longer (6 weeks). Although the PTR-PT group had better scores compared to the PTR group, the MAL-28 scale scores were significantly better in the PTR-PT group. On the other hand, it was determined that adding proprioceptive exercises to the rehabilitation program had the greatest effect on functional motor assessment and activity scales in the evaluation of the effect size.

Currently there are several methods recommended for upper extremity motor rehabilitation following stroke. Among them, bilateral training is particularly significant. In bilateral training, repeated tasks are performed with both affected and unaffected upper extremities with the aim of achieving a better motor function. On the other hand, Wu et al.[28] confirmed the utility of bilateral exercises for developing motor learning in their clinical study by using functional magnetic resonance imaging. In our study, proprioception-based bilateral education method was used. When bimanual movements are initiated simultaneously, the arms act as a unit that supersedes individual arm action, indicating that both arms are strongly linked as a coordinated unit in the brain. In addition, it is well known that even if one arm or hand is activated with moderate force, this can produce motor overflow in the other upper extremity such that both arms are engaged in the same or opposite muscle contractions although at different levels of force. Furthermore, studies have shown that learning a novel motor skill with one arm will result in a subsequent bilateral transfer of skill to the other arm. Taken together, these experiments suggest a strong neurophysiological linkage in the central nervous system that explains how bilateral (simultaneous and perhaps alternating) movements may improve motor learning[11,26-28].

There are many studies related to the proprioceptive training in patients with chronic stroke[11], and studies that use devices such as robotic[26,29] or virtual reality[30] applications are more prominent in the related literature. However, the devices used in such studies are expensive, whereas treatment plans, outcomes, and mechanisms have not been well-established. Therefore, the favorable effects of bilateral proprioceptive training on functional motor functions and activities that we observed in the present study are important in our opinion. Furthermore, consideration of that this method does not require any device should be documented as well as its convenience and inexpensiveness.

CONCLUSION

Although addition of the upper extremity proprioceptive training to the conventional treatment in patients with post-stroke chronic hemiplegia did not yield significant improvement in spasticity, it had favorable effects on functional outcomes. It also resulted in better outcomes compared to the conventional treatment alone with regard to improvement of frequency and quality of movement in upper extremities. These results indicate that proprioceptive treatment methods should be used as an adjunct to other treatments. It is clear that loss of functional motor skills and inadequacies in daily life activities are often observed in chronic hemiplegic patients. Therefore, we believe that further detailed studies are necessary to elaborate on the significance of the proprioceptive training as an adjunct to the conventional treatment for preventing the worsening of such deficits and minimizing future problems in these patients.

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