doi: 10.53446/actamednicomedia.1085728

Acta Medica Nicomedia

Cilt: 5 Sayı: 2 Haziran 2022 / Vol: 5 Issue: 2 June 2022
https://dergipark.org.tr/tr/pub/actamednicomedia

Research Article | Araştırma Makalesi

COMPARISON OF SENSORY PARAMETERS AND BALANCE IN PATIENTS WITH HEMIPLEGIAHE

HEMİPLEJİK HASTALARDA DUYUSAL PARAMETRELER VE DENGENİN KARŞILAŞTIRILMASI

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ABSTRACT

Objective: Hemiplegic patients experience loss of sensation and balance. In some patients, sensory and balance rehabilitation may vary depending on the treatment content they receive. It is a fact that the anatomical neuronal regions affected in such patients may cause different damages for each person with interneuronal relationships. In this study, we aimed to investigate the effects of proprioception and other sensory parameters and balance levels of hemiplegic patients who have completed treatment and are able to walk independently due to anatomically affected Fasciculus gracilis (FG) and Fasciculus cuneatus (FC).

Methods: A total of 24 patients were included (12 female and 12 male) who were diagnosed and treated with hemiplegia in this study. Participants consisted of 12 dominant and 12 non-dominant hemiplegic patients. Extremity length-circumference measurements, evaluation of vibration, two-point discrimination, balance and proprioception (Technobody prokin 252) senses of participants were evaluated.

Results: In the examination between balance and sensory parameters; a moderate positive correlation was found between proprioception-bipedal balance. In addition, a strong correlation was found between proprioception-left hemiplegia left leg balance ($p<0.05$).

Conclusion: In this study, we concluded that the effect rate of FC and FG will affect the sense of proprioception and that this sense is related to balance, which is one of the main parameters of mobilization, so that the general body balance and sensory integrity should be associated in the recovery process.

Keywords: Hemiplegia, proprioception, balance, sense

ÖZ

Amaç: Hemiplejik hastalarda duyu ve denge kayıpları meydana gelmektedir. Bazı hastalarda etkilenime bağlı olarak, gördükleri tedavi içeriğine göre duyu ve denge rehabilitasyonları değişebilmektedir. Bu tür hastalarda etkilenen anatomik nöronal bölgelerin internöronal ilişkilerle beraber her kişi için farklı hasarlar doğurabileceği bir gerçektir. Bu çalışmamızda tedavisini tamamlamış ve bağımsız yürüyebilen hemiplejik hastaların anatomik olarak Fasciculus gracilis (FG) ve Fasciculus cuneatus'un (FC) etkilenmesine bağlı olarak özellikle propriyosepsiyon duyularının etkilenme oranını, diğer duyu parametreleri ve denge düzeyleri ile ilişkisini araştırmak amaçlanmıştır.

Yöntem: Çalışmaya hemipleji tanısı konulmuş ve tedavi görmüş 12'si kadın ve 12 erkek olmak üzere toplam 24 hasta dahil edilmiştir. Katılımcılar 12'si dominant ve 12'si non-dominant hemiplejik hastalardan oluşmaktadır. Katılımcıların; ekstremite uzunluk-çevre ölçümleri, vibrasyon duyusunun değerlendirilmesi, iki nokta diskriminasyonun değerlendirilmesi, denge duyusu ve propriyosepsiyon duyusunun değerlendirilmesi (Technobody prokin 252) yapılmıştır.

Bulgular: Denge ile duyu parametreleri arasında yapılan incelemede; propriyosepsiyon ile iki bacak denge arasında pozitif yönlü orta dereceli ilişki ve propriyosepsiyon ile sol hemipleji sol bacak dengesi arasında güçlü ilişki saptanmıştır ($p<0,05$).

Sonuç: Çalışmamızda elde ettiğimiz sonuçlara göre FC ve FG'nin etkilenme oranı propriyosepsiyon duyusunu etkileyeceğinden ve bu duyunun da mobilizasyonun temel parametrelerinden denge ile bir ilişkisi olduğundan bu tür hastalarda iyileşme sürecinde genel vücut dengesiyle duysal bütünlüğün ilişkilendirilmesi gerektiği kanaatine varılmıştır.

Anahtar Kelimeler: Hemipleji, propriyosepsiyon, denge, duyu

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Submitted/Başvuru: 10.03.2022 • **Accepted/Kabul:** 14.04.2022 • **Published Online/Online Yayın:** 27.06.2022

Introduction

Balance impairment, which is one of the important problems of patients after stroke, is due to decreased muscle strength and decreased sensory information from the affected extremity.[1] Peripheral sensory receptors, proprioceptive joint receptors, muscle stretch receptors and vibratory receptors; provides information on gravity, surface, position, movement of joints and muscles.[2] However, various sensory disorders are also seen as a common symptom.[3]

Balance problems due to developing hemiplegia is a problem frequently experienced by patients. Balance is a mechanism that provides our orientation in three-dimensional space and accordingly adjusts our body posture to prevent falling. The basis of the balance system is the perception of the place and position we occupy in space.[4] This perception that maintains balance is provided by the evaluation of impulses from three sources in our brain. The somatosensory/proprioceptive, visual and vestibular systems process in harmony to control the balance.[3] As a natural consequence, balance is impaired in hemiplegic and hemiparetic patients. Increased postural sway, greater load on the nonparetic extremity, decreased muscle strength and decreased sensory information from the affected lower extremity lead to impaired balance.[5]

In chronic hemiplegic patients, loss or decrease in the sense of proprioception can be observed along with the loss of other senses. Proprioception is a sense of bodily movement position that includes a sense of position (joint position sense) and a sense of movement (kinesthesia). Increased proprioceptive information reaches the central nervous system via afferent pathway which contributes to movement and postural control.[4] Proprioception senses can be evaluated as a subgroup of somatosensory senses such as pain, temperature and touch.[6] It is impaired in the majority of patients after stroke. Because proprioception is critical to movement control and functioning, it is important to understand the role of proprioception in recovery after stroke.[7]

Two-point discrimination (2PD), a sense suggesting tactile acuity, is a function of touch involving peripheral and cortical mechanisms. Two-point discrimination, a sense suggesting tactile acuity, is a function of touch involving peripheral and cortical mechanisms. The TPD test evaluates the ability to distinguish between two light touch stimuli applied to the skin at the same time with equal pressure.[8] Tactile acuity is dependent not only on peripheral mechanisms but also on primary somatosensory cortex cells. Changed response profiles in primary somatosensory cortex neurons are expressed as "cortical reorganization".[7] Therefore, 2PD is used to evaluate not only cutaneous innervation but also central somatosensory function. It is an indicator that provides information in the evaluation of the status and treatment processes of hemiplegic patients.[8]

According to the severity of the disease in hemiplegia patients, the proprioception and balance sense loss carried by fasciculus cuneatus and gracilis can be seen in different intensities.[3] In the treatment process, apart from the treatments for the muscles, bones and joints; especially the sensory and balance rehabilitation parameters may change.[4] The aim of this study was to investigate the relationship between the sense of proprioception, the sensory parameters and the acquired balance values of the rehabilitation patients with hemiplegia.

Methods

This study was approved by Ethical Committee of Non-Invasive Clinical Research at Kocaeli University (2018/23). A total of 24 patients, 12 female (age: 32.75±13.89) and 12 male (age: 49.08±13.07) were included in the study, diagnosed and treated for hemiplegia. The volunteers participating in the study consisted of 12 dominant and 12 non-dominant hemiplegic patients. Patients who could not walk independently were not included in the study. The patients who participated in the study were diagnosed, treated and controlled in the physical therapy clinic. All measurements were made separately for the affected and the intact side.

Evaluation of Vibration Sense

Vibration sense are felt when a vibrating diapason is touched to the skin or when a faradic current is applied.[9] For the patients to learn the vibration, a diapason was first touched on their clavicles. Afterwards; vibration was applied to the hand phalanx, patella, tibia and ankle with a 256 Hz diapason and it was asked whether it could detect it. As soon as the diapason was touched to the determined areas and the vibration stopped, the measurement was made with a stopwatch in seconds.

Evaluation of Two-Point Discrimination

The two-point discrimination (2PD) test is a quantitative test for evaluating tactile acuity. It is widely used in the clinic to assess the severity of peripheral nerve injuries and to monitor patients' recovery and response to treatment.[8] In our study, measurements were made for all extremity regions and a criminator was used for two-point discrimination. After the necessary information about the evaluation was given to the patients, the measurement was first shown and taught in the patient's hand with the eyes open. The patient was evaluated in a sitting position with eyes closed. The application was performed on fingertip, back of finger, palm, back of hand, femoral area, leg area and back of foot, and the patient was told to distinguish between odd and even pairs. Double trials were performed and after each study, it was waited for 4-5 seconds for optimization.

Evaluation of the Proprioception

Computer aided Tecnobody Prokin 252 (TecnoBody, Bergamo, Italia) device was used for the evaluation of proprioceptive sense. The "Proprioceptive Assessment" test included in the device software was used to measure dynamic balance performance values. The level of the device has been adjusted to 5 difficulty levels for testing. The patients were asked to take 2 full turns between 15-30 seconds of the figures appearing on the screen of the device. A short trial was conducted before the test. The proprioception sense test was performed in the bipedal stance. In order for the patients to take the optimum position, the distance of the feet was determined based on the lines on the x and y axis on the platform and the feet were fixed by the tester. The resulting value, it shows the rate at which the patient exceeds the limits of the path to be followed.

Evaluation of Balance

In order to measure the static balance performance, the "Stabilometry–Kinesis Graph" test on the Tecnobody Prokin 252 (TecnoBody) device was applied to the patients. Static balance test was performed on the dominant leg and the non-dominant leg, respectively, in the fixed plane. The feet of the patients were fixed to the center of the platform by the tester with reference to the lines on the x and y axis on the platform. The static balance score of each patient was obtained from the data by adding the forward-backward standard deviation and right-left standard deviation.

Statistical analysis

In the statistical evaluation of our results, Kolmogorov-Smirnov analysis was performed for the normal distribution test. Independent T-Test was applied for those with normal distribution. Mann-Whitney U statistic method was used for values that did not fit the normal distribution. Pearson correlation test was applied between the variables. Statistical analysis SPSS 22.0 (IBM, Package program) was used.

Results

Participants; 12 female and 12 male, 12 right hemiplegia 12 left hemiplegia and 24 have right dominant extremities (Table 1).

Table 1. Demographic information of the patients

N=24		N
Gender	Female	12
	Male	12
Affected Side	Right	12
	Left	12
Dominant Side	Right	24

The mean height of the patients participating in the study is 173.45±8.47 cm, their mean weight is 82.88±16.33 kg, the mean of the shoulder circumference is 117.15±11.57 cm, the mean of the arm circumference is 29.98±3.89 cm, mean forearm circumference measurement is 27.00±2.76 cm, mean chest circumference measurement is 100.71±11.24 cm, average abdominal circumference measurement is 96.13±15.58 cm, mean hip circumference measurement is 105.04±12.19 cm, mean calf circumference 37.69±3.58 cm, mean arm length measurement 34.58±2.47, mean forearm length measurement 29.19±2.63 cm, hand length mean 18.42±1, 44 cm, thigh length measurement 43.10±4.46 cm, leg length measurement 43.50±3.36 cm, foot length measurement averages 25.98±3.89 cm (Table 2).

Table 2. Anthropometric measurements of the patients

N=24		*WA±SD
Height (cm)		173.45±8.47
Weight (kg)		82.88±16.33
Circumference (cm)	Shoulder	117.15±11.57
	Arm	29.98±3.89
	Forearm	27.00±2.76
	Thorax	100.71±11.24
	Abdomen	96.13±15.58
	Hip	105.04±12.19
	Calf	37.69±3.58
Length (cm)	Arm	34.58±2.47
	Forearm	29.19±2.63
	Hand	18.42±1.44
	Thigh	43.10±4.46
	Leg	43.50±3.36
	Foot	25.98±3.89

*WA: Weighted average, SD: Standard deviation

Sensory evaluations of the patients (Table 3) participating in the study; fingertip 2PD mean 2.17±0.96 mm, dorsum of finger 2PD mean 4.46±1.56 mm, palm 2PD mean 8.25±3.02 mm, dorsum of hand 2PD mean 20.63±5.68 mm, femoral area 2PD mean 40.83±2.41 mm, leg 2PD mean 40.42±1.41 mm, dorsum of foot 2PD mean 50.00±2.95 mm, hand phalanx diapason mean 9.37±4.51 sec, patella diapason mean 3.46±4.84 sec, tibia diapason mean 4.08±4.37 sec, ankle diapason mean 4.49±4.30 sec. The mean proprioception score was found to be 9.18±4.00.

Table 3. Sensory evaluation of patients

N=24		*WA±SD
Two-Point Discrimination (cm)	Fingertip	2.17±0.96
	Dorsum of finger	4.46±1.56
	Palm	8.25±3.02
	Dorsum of hand	20.63±5.38
	Thigh	40.83±2.41
	Leg	40.42±1.41
	Dorsum of foot	50.00±2.95
Diapason (sec)	Hand Phalanx	9.37±4.51
	Patella	3.46±4.84
	Tibia	4.08±4.37
	Ankle	4.49±4.30
Proprioception (Score)		9.18±4.00

*WA: Weighted average, SD: Standard deviation

In the examination between balance and other sensory parameters, a moderate positive correlation was found between proprioception and balance between two legs (r=0.678; p<0.001) and a strong correlation between proprioception and left hemiplegia left leg balance (r=0.718; p=0.009), (Table 5). Also, no correlation was found between right leg balance and proprioception values of right hemiplegic patients (p>0.05) (Table 4). Bilateral balance, hemiplegic side balance and proprioception parameters were not associated with other parameters (p>0.05), (Table 5).

Table 4. Statistical relationship between sensory parameters and balance

Sensory Parameters	Bipedal Balance		Right Hemiplegia Right Leg Balance		Left Hemiplegia Left Leg Balance	
	r value	p value	r value	p value	r value	p value
2PD Fingertip	0.070	0.745	0.332	0.292	0.79	0.807
2PD Dorsum of finger	-0.072	0.739	0.473	0.121	-0.278	0.382
2PD Palm	-0.224	0.292	0.284	0.371	-0.388	0.212
2PD Dorsum of hand	0.181	0.398	0.332	0.292	-0.017	0.959
2PD Thigh	0.198	0.355	0.000	1	-0.005	0.987
2PD Leg	0.065	0.761	0.000	1	-0.065	0.840
2PD Foot	0.292	0.166	0.000	1	0.238	0.456
Proprioception	**0.678**	**<0.001**	0.496	0.101	**0.718**	**0.009**
Diapason Hand Phalanx	-0.128	0.551	-0.313	0.323	-0.180	0.576
Diapason Patella	0.199	0.352	0.455	0.137	0.055	0.865
Diapason Tibia	0.380	0.067	0.002	0.996	0.237	0.459
Diapason Ankle	0.347	0.097	0.004	0.991	0.244	0.444

*2PD: Two-point discrimination

Table 5. Correlation analysis

		Bipedal Balance		Hemiplegic Side Balance		Proprioception	
		r value	p value	r value	p value	r value	p value
Diapason	**Hand Phalanx**	-0.128	0.551	-0.175	0.414	-0.007	0.976
	Patella	0.199	0.352	0.149	0.488	0.287	0.175
	Tibia	0.380	0.067	0.097	0.653	0.329	0.117
	Ankle	0.347	0.097	0.037	0.865	0.309	0.142
***2PD**	**Fingertip**	0.070	0.745	0.300	0.155	0.058	0.788
	Dorsum of finger	-0.072	0.739	0.212	0.321	-0.033	0.880
	Palm	-0.224	0.292	0.029	0.865	-0.038	0.860
	Dorsum of hand	0.181	0.398	0.318	0.130	0.214	0.316
	Thigh	0.198	0.355	0.087	0.685	-0.036	0.869
	Leg	0.065	0.761	-0.011	0.959	0.022	0.920
	Dorsum of foot	0.292	0.166	0.169	0.430	0.146	0.496
Age		0.100	0.643	0.286	0.176	0.224	0.292
Height		0.114	0.595	-0.033	0.877	0.122	0.571
Weight		0.195	0.362	0.124	0.565	0.282	0.182
Gender		-0.229	0.281	-0.226	0.289	-0.223	0.295

*2PD: Two-point discrimination

Discussion

Typically, clinical conditions that affect motor and sensory aspects of one half of the body may occur in the form of hemiplegia after stroke. The frequency of hemiplegia is quite high in the list of chronic diseases seen in the World.[4] The clinical conditions caused by stroke can radically change the life standards of hemiplegic patients. The negativities that occur after hemiplegia such as inability to walk, can be seen as lack of mobilization, loss of sensation and loss of muscle strength.[5]

There are two separate sensory pathways that inform to the brain about muscle movement, joint position, and objects we come into contact with. Both of these pathways start with receptors and carry information to the central nervous system about muscle tension, joint position-movements, skin vibration, tactile and pressure senses.[3] These receptors include muscle spindles, golgi tendon organs, pacinian corpuscles, meissner corpuscles and other encapsulated receptors found in muscle, tendons, ligaments, skin, and joints. Information on static position comes primarily from muscle spindle afferents, whereas kinesthetic sensation is transmitted from both joint afferent and muscle spindles.[7] Pacinian corpuscles perceive vibration and meissner corpuscles superficial touch sensation. Most proprioceptive receptors are innervated by large diameter myelinated fibers. The cell bodies of these peripheral nerve fibers are in the dorsal root ganglion and the central parts also enter in the medial part of the dorsal root region.[10]

Proprioception is impaired in a large percentage of individuals after stroke.[4] It has been reported that the prevalence of proprioceptive disorders ranges from 30% to 48% in individuals with upper extremity affected after stroke.[11] Because a healthy proprioception sense is critical to movement control and functioning, it is important to understand the role of it in recovery after stroke.[3] Proprioception is the perception of position, movement and force created by the body. Position perception indicates awareness of the relative position of body parts in space. Loss of this sense is associated with poor clinical outcomes.[11] It is stated that the functional recovery of the affected upper extremity after stroke is significantly negatively correlated with the level of proprioception sensory impairment and positively correlated with the initial motor ability and mental state.[12] In another study, the close relationship between motor skills and functional abilities to the sense of proprioception in patients with chronic hemiplegia was emphasized.[7]

A study of individuals with chronic paralysis looked at whether the dominant or non-dominant side of limb sensory dysfunction was affected. It has been stated that functional disorders are not limited to the affected side only. It has been reported that the unaffected sides of chronic hemiplegia patients also have impairments in proprioception and motor functions compared to the healthy control group.[13] Within this scope; we aimed to investigate the relationship between the sense of proprioception carried by FG and FC with balance and other sensory parameters. In this context, we investigated the balance and sensory parameters of hemiplegic patients and their relations with the dominant side in our study. We determined that there is a statistically positive correlation between proprioception and bipedal balance. Moreover; We determined a positive correlation between left leg balance sense and proprioception sense in patients with left hemiplegia. It is stated that the loss of proprioceptive afferents can affect the control of muscle tone and impair postural reflexes.[1] Considering the importance of proprioception for motor control[4] , it is also emphasized that treatments aimed at restoring motor function after stroke should focus on training the proprioceptive sense.[2,14] In our study, the statistical relationship between proprioception and balance sense was revealed, and no statistical relationship was found between the dominant and non-dominant sides.

Kinesthetic illusions can occur due to our senses of sight, touch, pressure, temperature, two-point discrimination and vibration especially in healthy people.[9] Vibration sense is also used as a quantitative assessment test in patients with post-stroke hemiplegia. Sensory receptors (mostly Pacinian and Meissner bodies) convert the vibration into a neural signal. Demyelinating diseases can prolong the nerve refractory period and impair the ability to encode higher frequencies. Therefore, testing vibration sense is a very sensitive parameter of polyneuropathy.[7] It is known that 'focal muscle vibration' applications in hemiplegic patients increase the excitability of the primary motor cortex and are applied in the treatment of spasticity.[15] Another important problem of hemiplegic patients is loss of somatosensation, which is stated as a factor that complicates the balance adjustment of stroke patients.[4]

Approximately 65% of patients with hemiplegia have decreased tactile and tactile senses. Moreover; pain, temperature and sense of touch are also reduced.[16] The senses are vital and play an important role in performing functional movements. Recovering motor control is a compound and complex process. For this purpose, vibration sense is used as one of the rehabilitation methods.[17] It is stated that segmental muscle vibration facilitates the generation of impulses carried by Ia nerve fibers as a result of facilitating muscle spindle stimulation. The applied vibration therapy can alter the activation of the corticospinal pathway by facilitating Ia sensory inputs, managing intracortical inhibition and activating sensory inputs to the primary motor cortex.[16]

In another study, transcranial magnetic stimulation was used after low amplitude vibration was applied to the flexor carpi radialis muscle and intrinsic hand muscles. It was shown that the excitability of the primary motor cortex was increased.[18] In this regard; in the examination made between balance and other senses, a statistically positive correlation was found between proprioception and balance levels (both legs balance, left leg balance) in our study. Nevertheless, no statistically significant relationship was found between balance, vibration and 2PD senses.

Proprioception training is applied to make the sensory pathways work more actively in stroke patients.[4] Methods such as video proprioception exercises and gait performance exercises are used especially on chronic stroke patients in the literature.[6,7] The positive correlation relationship between proprioception and balance, which is one of the results of our study, also supports this approach. It can be thought that any rehabilitation method for the development of proprioception sense may affect balance and mobility with interneural connections.

In addition to the known relationship between muscle weakness[5] and balance disorder in the post-hemiplegia period, proprioception sensory dysfunction significantly affects balance in patients with stroke.[14] According to the results we obtained; a positive and significant correlation was found between the bipedal balance parameters and the proprioception, which is one of the sensory parameters ($p<0.05$). No statistically significant correlation was found between the bipedal balance parameters and other sensory parameters ($p>0.05$). A positive and significant correlation was found between left hemiplegia-left leg balance and proprioception, one of the sensory parameters ($p<0.05$). No statistically significant correlation was found between left hemiplegia-left leg balance, right hemiplegia-right leg balance parameters and other sensory parameters ($p>0.05$).

Significant positive correlation between proprioception and balance sense parameters, it has led to the opinion that may have an effect on the balance. Since proprioception has a relationship with balance, which is one of the basic parameters of mobilization, it was concluded that the general body balance and sensory integrity should be associated with the recovery process in hemiplegic patients. In this context, it should be considered that these parameters can also be measured and affect the balance in the applications of exercise and rehabilitation programs for balance especially in patients with hemiplegia. In addition; patients' feeling better physically, emotionally and psychologically will help increase their daily living activities and increase the patient's quality of life.

Compliance with Ethical Standards

All participants or their relatives signed written consent before initiation of the study. This study was approved by Ethical Committee of Non-Invasive Clinical Research at Kocaeli University (2018/23).

Conflict of Interest

The authors declare no conflicts of interest.

Author Contribution

Authors contributed equally to this work.

Financial Disclosure

The authors declared that this study has received no financial support.

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