T.C.
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EFFECTS OF SENSORY TRAINING AND ELECTRICAL STIMULATION IN SOLE OF THE FOOT ON PROPRIOCEPTIVE AND CORTICAL SENSATIONS IN PATIENTS WITH ACUTE HEMIPLEGIA

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APPROVAL

This thesis has been deemed by the jury in accordance with the relevant articles of Yeditepe University Graduate Education and Examinations Regulation and has been approved by Administrative Board of Institute with decision dated 18/12/2019 and numbered 2019/19-17.

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DECLARATION

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree except where due acknowledgment has been made in the text.

Cansu HAYIROĞLU

DEDICATION

I would like to dedicate my thesis to my dear husband Oğuzhan HAYIROĞLU and also I thank to my loving parents Nilüfer ERDURAK and Ergun ERDURAK for their support.

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BMI	Body Mass Index
EG	Electric Stimulation Group
GTO	Golgi Tendon Organ
SG	Sensory Training Group
SD	Standart Deviation
TENS	Transcutaneous Electrical Nerve Stimulation

ABSTRACT

HAYIROĞLU, C. (2019). Effects Of Sensory Training In The Sole Of Foot And Electrical Stimulation On Proprioceptive And Cortical Sensations In Patients With Acute Hemiplegia. Yeditepe University, Institute of Health Sciences, Department of Physiotherapy and Rehabilitation Master Thesis, Istanbul.

The aim of this study was to investigate the effects of the sole of foot sensory education and electrical stimulation on proprioceptive and cortical senses in patients with acute hemiplegia, applied 5 days per week for 3 weeks. In the study, 15 subjects with an average age of 69.4±8.3 years were included in the sensory education group and 15 subjects with an average age of 65.8±7.2 years were included in the electrical stimulation group. In addition to neurodevelopmental treatment, a group was given sensory training, while the other group received electrical stimulation. Patients were evaluated twice before and after treatment. The cognitive level of the patients was evaluated with Mini Mental Test and the sole of foot sensations which are cortical and proprioceptive were evaluated with sensory tests. In our study's; data analysis "Statistical Package for Social Sciences" (SPSS) Version 25.0 program was used. As a result, there was a significant improvement in all proprioceptive and cortical senses in both groups before and after the study ($p \leq 0.05$). When comparing two groups, it was found that the sensory group was superior to the electrical stimulation group only in the sense of passive motion ($p \leq 0.05$). There was no significant difference between the two groups in other senses ($p > 0.05$).

Keywords: Electrical stimulation, sensory education, sensory evaluation, stroke, proprioception

ÖZET

HAYIROĞLU, C. (2019). Akut Hemiplejik Hastalarda Ayak Tabanı Duyu Eğitimi ve Elektrik Stimulasyonun Proprioseptif ve Kortikal Duyular Üzerine Etkileri. Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü Fizyoterapi ve Rehabilitasyon Bölümü Yüksek Lisans Tezi, İstanbul.

Bu çalışma, akut hemipleji hastalarında haftanın 5 günü 3 hafta boyunca uygulanan ayak tabanı duyu eğitiminin ve elektrik stimulasyonun proprioseptif ve kortikal duyular üzerindeki etkisinin araştırılması amacıyla planlanmıştır. Çalışma kapsamında duyu eğitimi grubuna yaş ortalaması 69.4±8,3 yıl olan 15 birey, elektrik stimulasyon grubuna yaş ortalaması 65,8±7,2 yıl olan 15 birey dahil edilmiştir. Bir gruba Nörogelişimsel Tedaviye ek olarak duyu eğitimi verilirken, diğer gruba elektrik stimulasyon uygulanmıştır. Bireyler tedavi öncesinde ve tedavi sonrasında olmak üzere iki defa değerlendirmeye alınmıştır. Hastaların bilişsel düzey Mini Mental Test ile, ayak tabanında proprioseptif ve kortikal duyular duyusal testler ile değerlendirilmiştir. Analizlerimiz SPSS Version 25.0 programı kullanılarak gerçekleşririlmiştir. Çalışma sonunda her iki grup öncesi ve sonrası olmak üzere kendi içinde kıyaslandığı zaman tüm proprioseptif ve kortikal duylar üzerinde anlamlı iyileşme sağlanmıştır ($p \leq 0,05$). İki grup karşılaştırıldığında duyu grubunun, yanlızca pasif hareket duyusunda elektrik stimulasyon grubuna üstün olduğu bulunmuştur ($p \leq 0,05$). Diğer duyularda iki grup arası anlamlı bir farklılık bulunamamıştr ($p>0.05$).

Anahtar kelimeler: Duyu eğitimi, duyusal değerlendirme, elektrik stimulasyon, inme, propriosepsiyon

1.INTRODUCTION AND PURPOSE

Hemiplegia; sensory and motor functions characterized by impairments in mental abilities and speech. Hemiplegia usually manifests itself in the form of sensation and motor integration disorders in addition to the balance and perception problems in the whole body with the loss of movement and sensation in the upper and lower extremities on the opposite side of the brain hemispheres. (1) Neurological loss in stroke patients depends on the type of stroke, the area of the brain affected, and the size of the lesion area. (2, 3)

Hemiplegia is the most common neurological problem in the world population and is the third most common cause of death. (1) Physiotherapy and rehabilitation approaches that starts early in the treatment of a stroke that leads to various deficiencies are very important. Stroke rehabilitation aims to improve functional independence by providing correction of related activities in walking and personal care of sensorimotor disorders. (4) After the stroke, the loss of motor in patients was accompanied by sensory problems as well, and close to 50% of stroke individuals experienced sensory problems, especially of tactile and proprioceptive discriminations. (5)

According to Sterzi's epidemiological survey, the somatic sensation is impaired in 37% of patients with a right hemisphere lesion and 25% of patients with a left hemisphere lesion. (6)

In stroke rehabilitation, the goal is to provide the individual with the highest level of independence in daily life activities despite the current motor deficiencies. The aim of rehabilitation should be determined by evaluating the motor and functional status of the patients suitable for rehabilitation. (7)

In a limited number of studies in the literature, it is stated that sensory disturbance in the lower extremity adversely affects standing, walking speed, balance during ambulation and symmetrical gait. (8, 9, 10)

Neuromuscular and sensorimotor stimulation has been shown to improve motor recovery in both acute and chronic survivors of strokes. (11, 12) For optimal motor performance, environmental information generated by the different senses is essential. Sensory input also plays a key role in post-stroke motor recovery.(13)
Many of the movement retraining techniques used for people with stroke are based on the assumption of providing sensory feedback on quality. Sensory feedback ensures that skilled movements can be carried out and monitored for adaptability during the performance. (14)

Peurala et al. said that cutaneous stimulation had positive effects in the motor performance and sensorimotor recovery of the paretic limb in chronic stroke patients. (15)

While there is some evidence that sensory retraining is effective for stroke patients with foot sensory dysfunction, more research is needed to measure its effectiveness, especially in the acute period after stroke.

It is stated that post-stroke sensory training increases functionality. Patients who are given sensory education recover more rapidly. Mobility, balance and daily life activities become better and that the well-being of daily living activities can be maintained for up to 12 months. (16)

The aim of sensory training is to maximize patient learning through the connection between the environment and repetitive activities. Various human and animal experiments show plasticity in the somatosensorial area of the brain, and thus motor activities are becoming more qualified. Therefore, sensory rehabilitation should not be neglected in the patient program. (15)

Even years after stroke, the somatosensory deficit can be alleviated and rehabilitation for patients with stroke should include sensory rehabilitation for those with sensory deficits. (1) Nadia Bolognini et al. reported on current sensory-based approaches in post-stroke motor rehabilitation and makes recommendations for optimizing rehabilitation programs based on sensory stimulation. (13)

The electrical stimulation of the sensory amplitude was reported to enhance the recovery of sensorimotor after stroke. Improvements in arm function were described following electrical stimulation of the motor and sensory amplitude. (18, 19, 20)

Therefore, in this postgraduate thesis study, it is aimed to compare the effects of neurodevelopmental physiotherapy program with sensory education or electrical stimulation on the soles of the foot in individuals with hemiplegia on proprioceptive and cortical sensation.

Two hypotheses identified in the study:

H0: The patients participating in the sensory training did not have more beneficial effects on proprioceptive and cortical sensation in the sole of foot than participating in the electrical stimulation.

H1: The patients participating in the sensory training had more beneficial effects on proprioceptive and cortical sensation in the sole of foot than participating in the electrical stimulation.

2. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2. 1. Stroke

Stroke is a dysfunction that develops abruptly, regionally, or across the whole brain, without any other cause, except in view of the vascular cause. It can cause permanent damage to body functions and also death. Stroke which is the most common cause of death in the adult population after heart disease and cancer in the world is also the most important cause of disability. It may occur due to bleeding or obstruction in the brain vessels. In the region where the blood flow is cut off in the brain, the vital requirements cannot be met. Accordingly, that area of the brain loses its function and patients have various symptoms. In one half of the body, drowsiness, weakness, speech and visual disturbances, imbalance, changes in consciousness are some of them. (21)

Stroke is the major disease that leads to an increase in the number of people with motor or sensory impairment or loss of function. It leads to an increase in the number of people with impairment or loss of function, either motor or sensory. Up to 85% of stroke patients have an initial upper limb deficiency, and the recovery of upper limb function is often poor and only seen in less than half of patients. (22)

Information meetings for physicians in primary care health care should be held more frequently regarding ischemic stroke leading to the most important causes of mortality and morbidity in the world and in our country .(23)

Stroke affects the quality of life significantly. Quality of life is the way people perceive their situation in the whole of their culture and value judgments in connection with their goals, expectations, standards, interests. (24) The main goal of rehabilitation in stroke patients is to ensure that a person lives long-term, independent, safe, happy, productive and high quality life. (25)

2.1.1. Epidemiology and risk factors

Incidence of stroke in ages of 55-64 are 1,3-3,6/1.000, for age of 65-74 are 4,9-8,9/1.000, over 75 years of age are13,5-17,9/1.000. Prior to the age of 44, the first stroke is only 3-5% of among all strokes. The incidence of stroke in women between the ages of 55-64 is 2-3 times lower than in men. The difference is decreasing towards the age of 85. The black race stroke rate is higher than for the whites. (26)

There are two groups of risk factors that can be controllable and uncontrollable. Age, gender, low birth weight, race and genetic factors risk factors that can not be changed. Other certain risk factors include; hypertension, diabetes mellitus, smoking, dyslipidemia, atrial fibrillation, other heart diseases, symptomatic carotid artery stenosis, sickle cell anemia, postmenopausal hormone therapy, oral contraceptive use, diet and nutrition, and obesity. Patients who have been less certain than changeable risk factors are migraine, metabolic syndrome, alcohol use, drug dependence, sleep apnea, hyperhomocysteinemia, increased lipoprotein-A, hypercoagulability and inflammation-infection. (27)

Acute ischemic stroke is common in men, in older ages. The most important risk factors are hypertension and diabetes. Acute mortality and morbidity rates of ischemic strokes controlled in the emergency department are low. Patients with acute ischemic stroke are monitored in the emergency department for a long time. The late admission of patients to the emergency department is also negatively effective at these rates. (28)

Morbidity, mortality rates and the cost are higher in hemorrhagic stroke patients. Moving stroke patients as fast as possible with ambulances with improved medical equipment can reduce the catastrophic consequences of emergency services. (29)

In Turkish society, the majority of hypertension patients are under antihypertensive treatment, but they have a high risk of stroke. Stroke risk factors are listed as follows for Turkish society. Left ventricular hypertrophy, advanced age, high blood pressure, male gender, coronary heart disease, smoking, diabetes mellitus, high creatinine, low HDL, high blood glucose levels, geographic region, and obesity. (30)

2.1.2. Etiology

2.1.2.1. Ischemic stroke

Ischemic stroke, which accounts for 80% of all strokes, is due to artery occlusion. Toast ‘trial of org in 0172 in Acute Stroke Treatment’ classification as well as clinical findings it is widely used today as it is also involved in the etiology. (31)

a. Large-artery sclerosis (thrombosis or embolism):

50% of all ischemic stroke is due to extensive atherosclerosis. In this subgroup of ischemia, especially intracranial and less rare intracranial vessels and their bifurcation regions developed over the years due to the deterioration of the stability of atheroma plaques due to thrombosis in extremities and especially in cases of embolism from the artery to the artery focal cortical findings are revealed. (32)

b. Cardioembolism:

In cardioembolism, which accounts for 20% of all ischemic stroke, the cause of arterial occlusion which is embolism originating from the heart. Major clinical findings are sudden and sometimes accompanied by a mental disorder. There is a high risk of death. (32)

c. Small vessel occlusion (Lacunar):

Lacunar infarcts, small deep infarcts developed as a result of occlusion of perforan arteries, account for about 25% of all ischemic stroke. In patients with lacunar infarction, they usually occur with classic lacunar syndrome. The early prognosis of lacunar infarcts is better because they are small in size compared to other ischemic stroke types and their clinical condition is mild. However, in later periods there is progress in cognitive decline, dementia risk and increased mortality due to cardiovascular causes. Hypertension and diabetes mellitus are major risk factors for lacunar stroke. The use of antihypertensive drugs in combination with the modification of risk factors, antiplatelet and blood pressure control is important in the treatment of hypertension. (32)

2.1.2.2. Hemorrhagic stroke

Hemorrhagic strokes account for 20% of all strokes. 50% of the patients lose their lives in 2 days, while 1 in 5 of the survivors can be self-sufficient.

a. Intracerebral hemorrhage: This is the bleeding to the brain parenchyma. Bleeding is often seen due to avascular malformation, hypertension, substance, smoking, alcohol, etc. It causes mental disorders (coma-confusion). Nausea, vomiting, and speech disorders are accompanied. (33)

b. Subarachnoid hemorrhage: This is the bleeding to the brain membrane and cerebrospinal fluid. The most common cause of subarachnoid hemorrhage is trauma and aneurysm. It is caused by an explosive and sudden headache. Causes mental disorders (coma-confusion). Nausea and vomiting accompany. Neck stiffness is seen. (34)

2.2. Sensation

The body's sensations are called somatosensation. Different systems interact to give us body state information. The exteroceptive system senses stimuli applied to the body's skin; including mechanical stimuli for touch sensation, temperature sensation thermal stimuli, and pain sensation nociceptive stimuli. The interoceptive system provides basic information about internal body conditions such as temperature and blood pressure. These organic senses originate in and around the body's organs, including the receptors in the lining of muscles, the gastrointestinal system's outer layer, and the thoracic and abdominal cavity linings. Most of these receptors are susceptible to stretching alone, but some are sensitive to temperature and blood pressure changes. Lastly, the proprioceptive system senses the position of body parts through stretch receptors in the muscles, joints, tendons, and organs of balance within the inner ear. (35)

The sensory system provides information about the environment in which the individual is placed. The sensation can be classified by different methods into categories according to anatomical or functional criteria. A classification of anatomy categorizes sensory function into somatic and visceral components, each with general and particular subgroups. (36, 37)

Early in this century, Sherrington developed a more practical classification scheme. This scheme uses both anatomical criteria to separate exteroceptive and proprioceptive sensation, including end organ types and locations, as well as functional criteria such as stimulus types measured by each modality. A third sensory modality requires cortical analysis to provide a more complex interpretation of primary sensory information. All three types of sensation should be evaluated by each patient examined. (36, 37)

2.2.1. Exteroceptive sensation (superficial sensation): Exteroceptive sensations are tactile sensation, pain sensation and temperature sensation (hot and cold).

Exteroceptive system receptors found in the skin and named as cutaneous receptors. These cutaneous receptors are found as fingertips and palms in both hairy skin and hairless skin. They respond to a variety of stimuli including pressure, heat, cold, vibration, and pain associated with tissue damage. Hairy skin mainly contains primarily free nerve endings and Ruffini corpuscles but also Pacinian corpuscles and Merkel's disks are present. Hairless skin is more complex, with Meissner's corpuscles. Pacinian corpuscles, Ruffini corpuscles. Merkel's disks are also found in hairless skin. (35)

Skin is a complex and vital organ of the body, which is often underestimated in the sustainability of life. It consists of two primary layers; the epidermis and the dermis are from the surface down. There is a layer of subcutaneous fat below the cutaneous layers, which mainly contains fat and blood vessels.

Touch sensation is achieved by moving the skin causing low-frequency pressure or high-frequency vibration. Hairless skin's specialized receptors support fine touch discrimination and differ in their rate of stimulus adaptation, receptive field size, and cutaneous layer depth. (35)

2.2.2. Proprioceptive sensation (deep sensation): Proprioceptive sensations are joint position sense, vibration sense, kinesthesia (joint motion sense) and deep pain.

Proprioceptive system receptors found in the muscles, tendons, ligaments and joints. Joint position sense means joint sensibility; the perception of joint motions. Vibratory sense is the appreciation of vibration, a form of pressure sensation. The vibratory sensation enables the recognition of vibration from touch. The perception of form allows objects to be recognized by touch alone.(38) Kinesthesia means perception of muscular motion.

The term proprioception was named by Sherrington in 1960 and It is used to describe the movement of the body and its position in space with the help of receptors in the muscles and tendons. (39)

Proprioception was defined as a specialized touch variation that includes the sensations of joint movement and joint position. (40) In practice, it is the body's ability to use the sense of position and respond to stresses imposed on the body by changing posture and movement. (41)

Proprioception is the conscious or unconscious joint position awareness while neuromuscular control is the efferent motor response to sensory information. (42)

Ataxia is the clinical sign of proprioception dysfunction. General proprioception describes the position of muscles, joints and tendons due to the location of proprioceptors in muscle spindles and Golgi tendon organs. (43) The muscle spindle senses changes in the length of the muscle and the GTO characterizes changes in muscle tension. (44)

There are three proprioception elements with a separate peripheral representation of the receptor. First, muscle spindle receptors, cutaneous mechanoreceptors and joint receptors mediate the perception of limb movement. Second, muscle spindle receptors and cutaneous mechanoreceptors mediate perception of the limb position. And the third, corollary discharges and tendon organ receptors mediate the perception of a force of muscle contraction. (45)

2.2.3. Cortical sensations: Stereognosis, graphestesia, tactile localization, two-point discrimination.

Stereognosis means the ability to recognize and identify objects by feeling them. Loss of this ability, astereognosis, is generally regarded as a somatic sensation deficiency. (46)

Graphesthesia means the ability to recognize symbols written on the skin. The absence of this ability is termed graphanesthesia. (47)

Two-point discrimination means the ability to recognize simultaneous stimulation by two blunt points. The distance between the two points is measured to notice the patient's recognition ability. This makes it possible to distinguish two adjacent points on the skin. The sensitivity of two points varies across the surface of the brain. The most sensitive of the lips and fingertips and the least sensitive of the back. (48)

Tactile localization means the ability to localize stimuli to parts of the body. (49) Topagnosia is the absence of this ability.

These are the combined forms of the above senses integrated into the parietal cortex. However, examining cortical sensation may be helpful in situations where there is a question of whether the symptoms of a patient are due to a right hemisphere (cortical) process as opposed to a spinal cord or a peripheral process. In contrast to the primary sensory modalities for which there are specific peripheral receptors, these cortical sensory functions do not require much additional cortical integration.

Proprioception refers to the sense of position and motion of the limb, where kinesthesia is specifically referred to as the latter. For proper balance and motor control, proprioceptive feedback is critical. Innervated by fast Aα fibers, muscles have proprioception receptors involved. Muscle spindles consist of a bundle of thin muscle fibers in a capsule. Mechanosensitive afferents wrap around the fibers of the muscle and are activated by stretching so that their firing rate is proportional to the length of the muscle. The contraction of thin muscle fibers, which are motoneuron-innervated, can effectively modulate muscle spindle sensitivity. Golgi tendon organs, located between the muscle and tendons, sense muscle strength rather than length and is an important component of the reflex circuits. Joints are equipped with joint capsule receptors that senses tension but, interestingly, individuals with artificial joints still have a reasonable sense of the angle and movement of their artificial joint based on muscle spindle input. (50)

2.3. Sensory Evaluation

The sensory examination is the most difficult and subjective examination for the physician and patient. The patient should be relaxed and in a comfortable environment. Care must be taken to describe what is expected of the patient and to ensure anxious patients that the evaluation will not be painful. It is important to stop the examination at this point when the patient is fatigued and the attention and cooperation are inadequate. In such cases, when the patient is rested, the evaluation should be repeated.

Areas of abnormal sensation should be outlined, and findings should be carefully recorded on a body outline with a description of the stimuli used. (36, 37)

2.3.1. Subjective evaluation

If the patient is suffering from pain, the location, spread (from neck to arm, back to waist to leg and back to heel, in the form of transverse belt in the body), duration, quality (stabbing, compulsive, blunt, flammable), the relationship between motion and position and cough is asked whether it is increased by "limping-limping". These features can give you some clues about the nature of the pain and the location of the event.

2.3.2. Objective evaluation

2.3.2.1. Exteroceptive sense evaluation

a. Tactile: The patient closes the eyes then patient is examined by touching the desired side of the body with cotton. The patient is asked to tell you every time he feels the cotton. Hypoesthesia is thought to occur in areas where the patient does not feel. This examination is done by comparing the opposite extremity of the body. (36, 37, 51)

b. Pain: The patient closes the eyes. The patient is examined by touching the needle on the part of the body that is intended to be evaluated. The patient is asked to tell you every time he feels the needle. Hypoesthesia is thought to occur in areas where the patient does not feel. This examination is done by comparing the opposite extremity of the body. (36, 37)

c. Temperature: The diameter is equal to one of the two test tubes, hot, cold water is placed on the other, and the eyes are closed. The patient is first taught the heat difference of tubes. The patient is then asked to tell you which tubes are hot and which ones are cold. (37, 51)

2.3.2.2. Proprioceptive sense evaluation

a. Joint position sense: The patient's eyes are closed. One of the extremities is brought to a certain position and the patient is asked to bring the other extremity to a similar position.

b. Joint motion sense: The eyes are closed. One of the patient's fingers or toes are held and moved upside or downside. During this time, the patient is asked to indicate the direction of the move. The finger should not be held from the top and bottom. Otherwise, the patient can predict the direction of the movement by noticing the pressure change on the finger held during the movement. The rhythmic "up-and-down" movement should be avoided. In this case, the patient may automatically respond correctly. (36, 37, 84)

c. Vibration sense: It is done with a vibrating tuning fork. First, for the patient to learn the vibration the tuning fork is placed on the clavicle or sternum. Later, when the eyes are closed, the extremities are placed on a bone and asked whether they detect the vibration.

If it is perceived, this time the patient is asked to indicate the moment when the vibration ends. Thus, the time when the vibration is felt is determined. This period is about 20 seconds in normal youth. It should be remembered that vibration time is shortened in lower extremities as the age progresses. (37, 51, 85)

d. Deep pain: If the Achilles tendon is squeezed or the muscles are severely suppressed, it is investigated whether or not the pain is felt.

Romberg sign: A test used to look for a deep sense defect. When the patient closes the eyes, even though the feet are joined, the balance will deteriorate, the patient starts to shake and he can even collapse to the ground. Tabes dorsalis, m.spinais is associated with combined degeneration and sensory neuropathy. (36, 51, 71)

2.3.2.3. Cortical sense evaluation

a. Stereognosis: The ability to recognize an object from its shape, size and structural properties. During the examination, the patient's eyes should be closed. In the meantime, the patient is given objects such as key, pen, lighter and asked to name the objects. (36, 37, 51)

b. Two-point discrimination: The ability to perceive the points that are touched to the skin at the same time as two separate points with a blunt wig. Eyes should be closed during the examination. Normally, the two points at the fingertips of the hand can be detected at 5 mm distance, while this distance is up to 5 cm on the back of the foot. (36, 37, 86)

c. Graphesthesia: Recognition of a word or a number that was written using a blunt object on the skin while the eyes are closed. (87)

d. Tactile localization: When the eyes are closed, the ability to localize the touch on the different parts of the body is investigated. (88)

e. Tactile inattention: The patient closes the eyes. The right and the left half of the body is needled at the same time. The patient with tactile persistence perceives only one of them. This can be done in an alternative way. The needle is first touched to the suspicious side of the body. When the patient initially feels this, a second needle is placed on the other side of the body, the first needle becomes unnoticeable. (36, 37, 51)

All cortical sensory disturbances indicate parietal lobe disease.

2.4. Sensory Problems in Hemiplegia

Sensory problems arise from damage to the brain's right side or parietal and occipital lobes. Parietal lobe damage where the somatosensory cortex is located and thalamus and brainstem damage which relays sensory information to the cortex can cause sensation problems. Post-stroke sensory problems differ from person to person. (36)

2.4.1. Parietal lobe lesions

a. Primary somatosensory area (36, 52)

The primary somatosensory cortex is located in the parietal lobe, at the postcentral gyrus and the areas 3,1,2 of Brodmann. Touch sensation, two-point discrimination, pain, heat and proprioceptive senses are detected. Lips are represented in the largest area. Then the face, hand, thumb, arm, trunk and lower extremity comes. this is called 'Sensory Homonculus'.

b. Secondary somatosensory area (Somatic association area) (36, 52)

This center is located on the upper edge of the sulcus lateralis, starting from the sulcus centralis. It has a role in resolving sensory information. This area allows the shape and size of objects to be perceived by touch (stereognosis)

The function of the parietal lobe is to provide integration and interpret them. In the parietal lobe lesion, the sensation of pain and heat are not impaired because they are perceived at thalamus level. Higher sensory functions such as stereognosis, two-point discrimination, graphestesia, tactile localization have been impaired in cortical lesions. Tactical inattention is seen. This type of sensory disturbance is called cortical sensory disturbance.

In the primary somatic sensory area lesion, proprioceptive senses are completely lost, while pain, heat, senses are perceived as gross sense.

In the somatic association sense lesion, the perception of the shape, structure and size of the objects by touching is impaired. (stereognosis)

In the gyrus supramarginalis lesion, the ability to recognize objects by touching. In the opposite half of the body is lost (astereognosis). The patient forgets the other half of the body (neglect).

In gyrus postcentralis lesions, proprioceptive sensations are completely lost, especially pain and heat sensations are perceived as gross. The reason these senses are not lost is that they can be perceived as better as pure in the thalamus.

2.4.2. Thalamus lesions

This problem generally caused by hemiplegia, all sensory modalities are lost in the opposite side of the body, including the face. Especially the sensation of pain and heat-cold are impaired. Sensory defects and hemiplegia are on the same side of the body and can be very severe. This table is called as pure sensory stroke. (36, 53)

2.4.3. Brain stem lesions

The most common form is the loss of sensation of pain and heat in one half of the face and in the arms, legs and torso on the opposite side. The touching sensation is not impaired. Brain stem sensory defect is due to the lateral spinothalamic lesion and the descending sensory tractus of n.trigeminus. Usually the result of infarct in the side part of the bulbus. Other brain stem symptoms accompany the picture. (36, 54)

2.4.4. Sensory defects

Paresthesia is an abnormal sensation, such as burning, numbness, or tingling that occurs most often in the extremities, such as the hands, arms, legs, or feet. (55)

Dysesthesia means painful sensations caused by a non-painful skin stimulus such as a light touch or a gentle stroke over the body's affected areas. (56)

Tactile sensation defects are anesthesia, hypoesthesia and hyperesthesia. Anesthesia is a lack of sensation of the touch. Hypoesthesia means the decreased sensation of the touch. Hyperesthesia is an exaggerated sensitivity to touch. (57)

Pain sensation defects are analgesia, hypoalgesia and hyperalgesia. Analgesia describes a lack of sensibility to pain, Hypoalgesia means the decreased sensation of pain. Hyperalgesia is excessive sensitivity to pain. (58)

Temperature sensation defects are thermanalgesia, thermhypesthesia, thermhyperesthesia. Thermanalgesia is lack of temperature sensation. Thermhypesthesia defines decreased sensation of temperature. Thermhyperesthesia means the exaggerated sensation of temperature. (37)

Cortical sensation defects are astereognosis, graphanesthesia and atopognosis. Astereognosis is the inability by touch to recognize common objects like keys,coins and small blocks. Graphanesthesia is a tactile inability to recognize figures or letters written on the skin; it may be due to the spinal cord or brain disease. The inability to localize touch is called atopognosis .(38)

2.5. Transcutaneous Electrical Nerve Stimulation

Transcutaneous electrical nerve stimulation is a simple, inexpensive, self-administered, non-invasive analgesic technique widely used by physiotherapists. (59)

There are lots of TENS techniques including mostly conventional and others such as acupuncture-like TENS. intense TENS and burst TENS. (60)

In the gate control theory presented by Melzack and Wall, they revealed the presence of special nerve cells in the dorsal parts of the spinal cord and stated that these cells, called T cells, constitute the anatomical and physiological structure stones of the spinal cord pain portal. The activity in the thin, myelinated, slow-forward C fibers, which is considered responsible for pain transmission, tends to reach the brain through the spinal cord while the signal carried by the fibers of the heavy myelinated and fast-forward Aß are trying to close the pain door. This thick and thin peripheral T cells according to the effect of the fibers on the door either remain open, or closed, or remain partially. By using TENS in the clinic, the thick and rapidly transmitting fibers are stimed, which is aimed at stopping or reducing the pain transmission. (61)

The purpose of TENS is to activate nerve fibers selectively. When TENS generates a strong non-painful electrical sensation under the electrodes, maximum pain relief is achieved. Patients with implanted stimulators such as pacemakers are the main contraindication. (62)

TENS is the application of electrical current for pain control by electrodes placed on the skin. It can be applied with different frequencies, from low to high. Different frequencies used to activate analgesic mechanisms. Intensity can also vary from sensory to motor intensity. Sensory intensity is when the patient feels a strong but comfortable feeling without the contraction of the motor. It contains non-painful, high intensity motor contraction.

Stimulation of higher frequency is generally given at sensory intensity, and stimulation of low frequency is given at motor intensity. (63, 64)

a. Convantional TENS (High frequency (80 - 130Hz), low intensity), small pulse width (50-200µs): The purpose of conventional TENS is to stimulate large diameter non-noxious afferents (A-beta) to produce segmental analgesia. (62)

b. Acupuncture-like TENS (Low frequency (2-5Hz), high intensity, longer pulse width (100-400µs): The aim of acupuncture-likeTENS is to activate To stimulate small diameter cutaneous and motor afferents (A-delta) to produce extrasegmental analgesia. (62)

c. Intense TENS (High frequency, high intensity): The purpose of intense TENS is to activate small-diameter afferents by delivering TENS over peripheral nerves from the pain site at an intensity that is only tolerable to the patient. It produces counter irritation. (60)

3. MATERIAL AND METHOD

3.1. Subjects

The sample of the study consists of patients with acute hemiplegia that got diagnosed at most 6 months ago and who applied to EKSEN Sağlıklı Yaşam Merkezi Istanbul Turkey between September 2018 - June 2019. The average age of patients was 67,6 ± 7,75 years.

The average height was 165±7.1 cm. The average BMI was 27,95±3.45 kg/m2. The dominant side of all participants was mainly the right side.

The study included 30 patients with acute hemiplegia (Min-Max=50-80yrs). The patients who met inclusion criteria are divided into two groups. According to the simple randomization method, patients which have odd survey numbers involved to the neurodevelopmental treatment and sensory training group (SG) and the patients with even survey numbers are involved to the neurodevelopmental treatment and electric stimulation group (EG).

3.1.1. Inclusion criteria

- Participating to the study in a voluntary basis
- Patients with 50-80 years old
- A stroke diagnosis by a neurologist
- A stroke attack within 6 months
- Minimum 18 points from Mini Mental Test
- Medically stable

3.1.2. Exclusion criteria

- Unstable condition
- Other neurological or orthopaedic problems that will affect function other than stroke
- Uncontrolled hypertension
- Diabetic foot ulcers
- Part/total foot amputation

The study protocol was approved by the Yeditepe Üniversitesi Ethical Committee at the date of 04.10.2018 and the issue number was 907. (Appendix 4)

The aim and plan of the study were explained to the participants All participants joined the study on their free will and they gave their own written consent to participate in the test protocols of the study voluntarily and they signed a volunteer form. (Appendix 1)

3.1.3. The flow of research

We planned to have 34 acute hemiplegia patients for SG and EG who satisfied interventions. As for the first step, we separated the participants according to survey numbers. While the participants with odd survey numbers involved in the sensory training group (n=17) and the patients with even survey numbers are involved in the electric stimulation group (n=17).

After the end of the first assessment 15 sessions treatment program initiated with 34 participants. However, four individuals were excluded from the study due to various reasons and they did not complete the treatment program (Figure 1. The Flowchart Diagram).

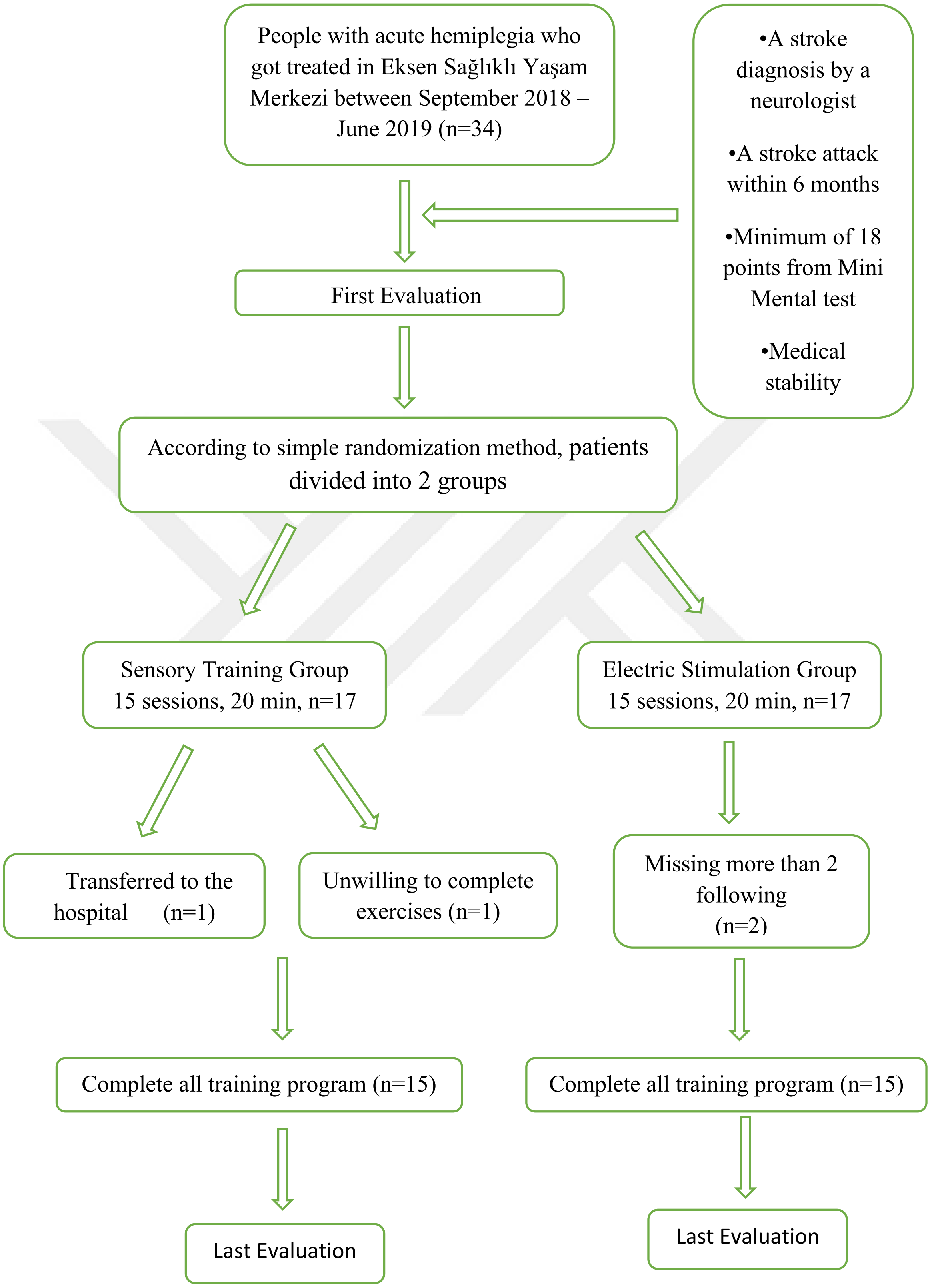


Figure 3.1. The Flowchart Diagram

3.1.4. Study protocol

All participants would be treated with a neurodevelopmental treatment approach where normal development steps are followed. In addition to neurodevelopmental treatment, 20 minutes sensory training for the first group and 20 minutes conventional tens for the second group would be given to 15 sessions for 5 days a week.

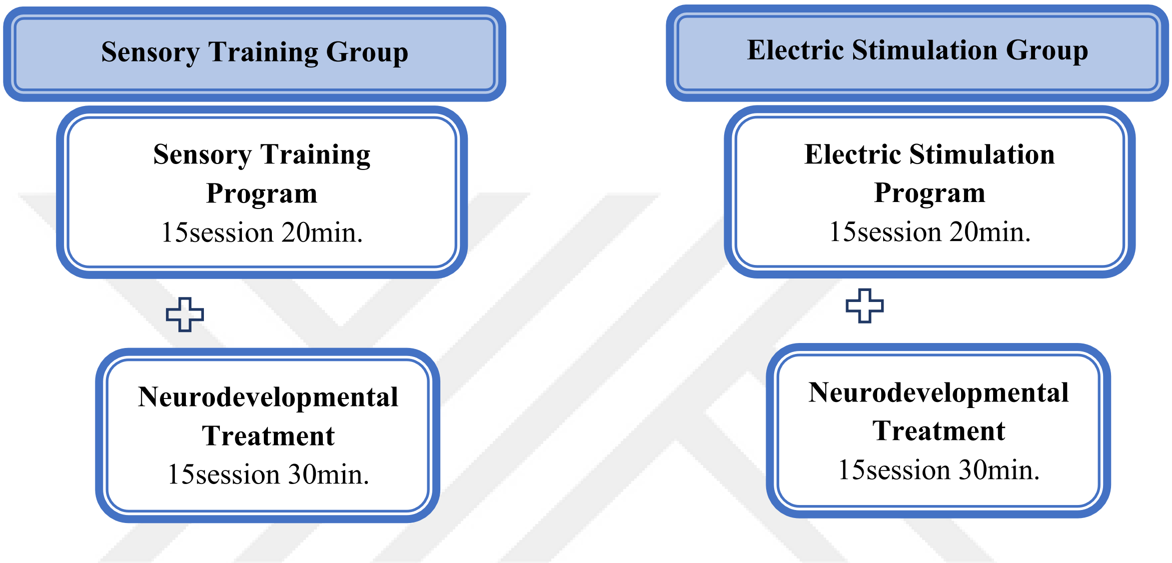


Figure 3.2. Interventions of Sensory Training Group and Electric Stimulation Group

3.2. Evaluation

All evaluations were performed by the same physiotherapist before and after 15 sessions of treatment under the same environmental conditions.

3.2.1. Structured questionnaire for patient's demographic characteristics

The structured questionnaire prepared by researchers applied to face to face interviews. The questionnaire included age, gender, education level, occupation, marital status, income level and health insurance to understand socio-demographic conditions of volunteers. The second part of the questionnaire was about their neurological stories, hemiplegic side, history of stroke, rehabilitation, how long it took, surgical operation, assistant device and the device type. (APPENDIX 2)

3.2.2. Assessment of cognitive level

A mini mental test was performed to evaluate the patient's cognitive level. This test would be used because it evaluates orientation, recording memory, attention and computation, remembering and language, orientation, praxis skills. In the test consisting of 30 questions and 30 points, a total of ≥25 points were considered normal, 21-24 points Light, 10-20 points medium and ≤9 serious cognitive disorders. (APPENDIX 3)

3.2.3. Assessment of sensation

3.2.3.1. Proprioceptive sense assessment

a) Position Sense: The patient's eyes are closed. One of the foot on the hemiplegic side of the patient is brought to a certain position and the patient is asked to bring the other extremity to a similar position. (In the case of correct response to 8 and above from ten attempts, the position sense is considered normal; correct response between 3-7, position sense is considered decreased; correct response 3 and below, the position sense is considered lost.)

b) Sense of Passive Motion: Eyes are closed. One of the patient's big toe is held on either side and moved up or down. During this time, the patient is asked to indicate the direction of the movement. (In the case of correct response to 8 and above from ten attempts, the sense of passive motion is considered normal; correct response between 3-7, the sense of passive motion is considered decreased; correct response 3 and below, the sense of passive motion is considered lost.)

Figure 3.3. Passive Motion Sense Evaluation

c) Vibration Sense: It is evaluated with a vibrating diapason. First, the patient to feel the vibration is placed on the clavicle or sternum. While the eyes are closed, the diapason is placed on the tip of the big toe of the hemiplegic foot, the patient is asked if the vibration is felt. If it is felt, this time the patient will be asked to indicate the moment when the vibration ends. Thus, the time it detects the vibration is determined.

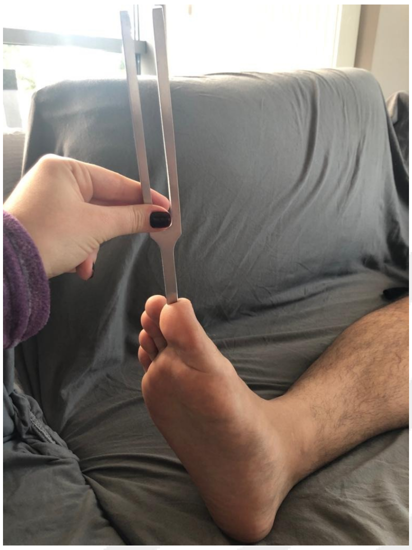


Figure 3.4. Vibration Sense Evaluation

d) Deep Pain: If the achilles tendon of the hemiplegic side is squeezed or the muscles are severely suppressed, it is investigated whether or not the pain is felt.

3.2.3.2. Cortical sense assessment

a) Two-point Discrimination: The points of the blunt wig are held against the hemiplegic sole of the foot at different distances from each other. Instruct the client to respond to each touch, by saying one point or two points. Eyes should be closed during the examination. When the patient feels two, it is noted how far away in cm from the wig.

b) Graphesthesia: The patient is asked to estimate a letter or number written the sole of the hemiplegic foot with a blunt object while the eyes are closed. (In the case of correct response to 8 and above from ten attempts, the sense of graphesthesia is considered normal; correct response between 3-7, the sense of graphesthesia is considered decreased; correct response 3 and below, the sense of graphesthesia is considered lost.)

c) Tactile Localization: Patients were stimulated on 10 different locations of the hemiplegic sole of the foot. They were asked to localize the touch. The response was recorded. (In the case of correct response to 8 and above from ten attempts, the sense of tactile localization is considered normal; correct response between 3-7, the sense of tactile localization is considered decreased; correct response 3 and below, the sense of tactile localization is considered lost.)

d) Tactile Inattention: The patient closes the eyes. The right and the left sole of foot are needled at the same time. The patient with tactile persistence perceives only one of them. This can be done in a second way. The needle is first touched to the hemiplagic foot. When the patient initially feels this, a second needle is placed on the other foot, the first needle becomes unnoticeable.

3.3. Intervention

All participants would be treated with a neurodevelopmental treatment approach where normal development steps are followed. In addition to neurodevelopmental treatment, 20 minutes sensory training for the first group and 20 minutes conventional tens for the second group would be given to 15 sessions for 5 days a week along 3 weeks.

3.3.1. Neurodevelopmental training

15 sessions, 20 minutes of neurodevelopmental treatment program was applied to all patients. In the treatment program, passive-active ROM and muscle strengthening exercises for lower and upper extremities were performed in the bed. Head, neck and shoulder mobilization exercises were performed. Abdominal, gluteal and back extensor muscles were strengthened. Bobath and PNF exercises were performed. Weight transfer exercises were performed. Sitting and standing balance were performed. In the sitting position, body rotation movements and reaching exercises were performed to the front and sides. Knee-locking exercises and walking training were performed in the patients who provided the balance of standing.

3.3.2. Sensory training

15 sessions, 20 minutes sensory training was applied to the first group. In the selection of the methods to be used in sensory education, attention was given to the fact that there is an active education including the training of deep and cortical senses. The following applications have been performed.

a. Different sized and thorny balls were applied in all directions along sole of the foot for 2 minutes.

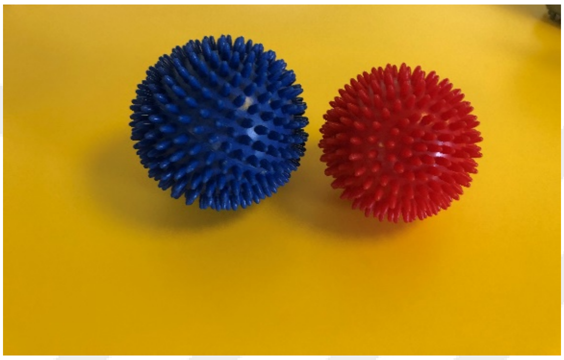


Figure 3.5. Different Sized and Thorny Balls

b. As a rigid and soft object, cotton and metal materials were rubbed and applied in every direction for 2 minutes throughout sole of the foot.

Figure 3.6. Rigid and Soft Object, Cotton and Metal Materials

c. The Wilberger brush was applied to sole of the foot for 2 minutes.

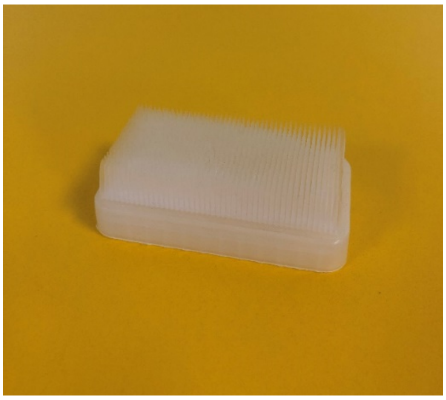


Figure 3.7. Wilberger Brush

d. A mechanical massage was applied to the foot for 5 minutes for the vibration sensation.

Figure 3.8. A Mechanical Massage Device

Figure 3.9. Using Mechanical Massage Device

e. Two different sized objects were placed under the foot and the patient was asked to predict the object. Then, according to the patient's response, feedback was received.

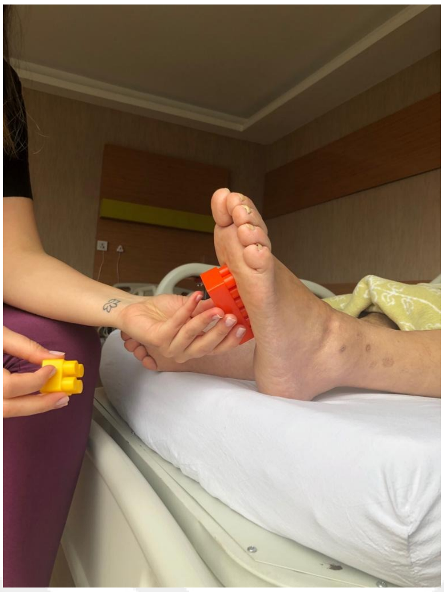


Figure 3.10. Two Different Sized Objects

f. Sensory input was applied to the boxes with different sizes of grain (rice-beans).

Figure 3.11. Different Sizes of Grain

g. 2 min of ice massage was performed.

h.5 min of therapeutic massage was performed.

Figure 3.12. Performing Therapeutic Massage

Figure 3.13. Performing Therapeutic Massage

3.3.3. Electrical stimulation

15 sessions, 20 minutes sensory training was applied to second group with TENS using BTL four channel muscle stimulator TENS 3 throughout tibialis posterior nerve on sole of the foot.

Figure 3.14. Application of Electric Stimulation with TENS Device

Data Analysis

In our study; data analysis “Statistical Package for Social Sciences” (SPSS) Version 25.0 program was used. Descriptive statistics, mean ± standard deviation (X ± SD) or percentages (%), were gathered. The level of significance was accepted as $p \leq 0,05$.

Statistical analysis was performed before and after treatment for parametric and non-parametric data with respectively Paired Sample T-test and Wilcoxon test. An independent-samples t test was used to compare physical features. A Chi-square test was used to assess categorical variables. An independent-samples t test and mann-whitney u test were used to compare of parametric and non-parametric variables between participants before interventions. A Wilcoxon test for non parametric variables and paired-samples t test for parametric variables were used to examine group differences in regard to pre and post test mean scores. A Mc Nemar Test was used to compare before and after treatment for categorical data.

4.RESULTS

The study included 30 acute hemiplegic patients who applied to Eksen Sağlık, Istanbul, Turkey between September 2018 and June 2019 and got diagnosed at least 6 months earlier.

The physical features (age, weight, height and body mass index (BMI)) of EG and SG are presented in Table 4.1. An independent-samples t test was used to compare physical features. There were no statistically differences in age, height, weight and BMI in two groups. ($p>0.05$)

Table 4.1. Distribution of average age, height, weight, and bmı values in sensory training and electric stimulation group

	Electric Stimulation (n=15) Mean±SD	**Sensory Training (n=15) Mean±SD**	**t**	**p value**
Age (yr)	65,8±7,2	69.4±8,3	-1.2	0.20
Height (cm)	165.6±11.1	166.6±6.9	-0.2	0.70
Weight (kg)	77.6±6.7	76.4±10.2	0.4	0.69
BMI (kg/m$^{2)}$	28.4±3.2	27.5 ± 3.7	0.7	0.47

Data expressed as mean ± standard deviation. BMI: Body mass index.

The gender, hemiplegic side, dominant side and education level in the study groups were given in Table 4.2. Chi-square test was used to assess clinical charactesistics. There were no statistically significant differences according to gender, hemiplegic side, dominant side and education level between two groups. (p>0.05)

Table 4.2. Clinical characteristics and sociodemographic features of patients in sensory group and electric stimulation group

		Electric Stimulation % (n)	**Sensory Training %(n)**	**λ^2**	**p value**
Gender	Female	40 (6)	40 (6)	0.0	1.00
	Male	60 (9)	60 (9)		
Hemiplegic Side	Right	33.3 (5)	40 (6)	0.1	0.70
	Left	66.7 (10)	60 (9)		
Dominant Side	Right	86.7 (13)	93.3 (14)	0.3	0.50
	Left	13.3 (2)	6.7 (1)		
Education Level	Illiterate	-	-	2	0.36
	Primary School	40 (6)	40 (6)		
	High School	20 (3)	40 (6)		
	University	40 (6)	20 (3)		

Data expressed as % (n).

The mini mental score and duration of hemiplegia of patients in the study groups were given in Table 4.3. An independent-samples t test and mann-whitney u test was used to assess parametric and non-parametric variables. There were no statistically significant differences between two groups. ($p>0.05$)

Table 4.3. Duration of hemiplegia and mini mental scores of patients in sensory group and electric stimulation group

	Electric Stimulation (n=15) Mean±SD	**Sensory Training (n=15) Mean±SD**	**Significance**
Duration (month)	2.3±2.02	2.03±1.56	p: 0.96 u:-0.40
Mini Mental Score	22.9±4.10	23±2.90	p: 0.96 t:-0.50

Data expressed as % (n)

An independent-samples t test and mann-whitney u test were used to compare of parametric and non parametric variables between participants of EG and SG before interventions. There was no statistically significant difference between the two groups in Table 4.4. (p>0.05).

Table 4.4. Comparison of proprioceptive and cortical senses between EG and SG before interventions

		Electric Stimulation (n=15) Mean±SD	**Sensory Training (n=15) Mean±SD**	**Significance**
Proprioceptive Sense	Position Sense	6.4±3.0	5.0±2.8	p: 0.18 u:-1.30
	Passive Motion Sense	6.8±1.8	5.3±2.3	p: 0.07 u:-1.80
	Vibration Sense	4.2±4.3	2.5±2.2	p: 0.57 u:-0.50
Cortical Sense	Two-point Discrimination Sense	6.9±2.8	7.5±2.6	p: 0.54 t:-0.60
	Graphestesia	3.1±1.4	3.9±1.9	p: 0.20 t:-1.30
	Tactile Localization	7.1±1.9	6.3±2.3	p: 0.33 u:-0.90

Data expressed as mean ± standard deviation.

Chi-square test was used to assess the deep pain and tactile inattention of individuals. There is no meaningful results were found in Table 4.5. ($p>0.05$).

Table 4.5. Characteristic of deep pain and tactile ınattention between EG and SG before interventions

		Electric Stimulation % (n)	**Sensory Training %(n)**	**λ²**	**p value**
Deep Pain	Positive	53.3 (8)	66.7 (10)	0.55	0.45
	Negative	46.7 (7)	33.3 (5)		
Tactile Inattention	Positive	26.7 (4)	60 (9)	3.30	0.65
	Negative	73.3 (11)	40 (6)		

Data expressed as % (n).

A Wilcoxon test for non parametric variables and paired-samples t test for parametric variables were used to examine group differences in regard to pre and post test mean scores of proprioceptive and cortical sense evaluation in Table 4.6. As per results, both electric stimulation group (EG) and sensory training group showed statistically significant difference in proprioceptive and cortical senses (p≤0.05).

Table 4.6. Comparison of proprioceptive and cortical sense evaluation for intragroup variables between EG and SG

			Electric Stimulation (n=15) Mean±SD	**Significance**	**Sensory Training (n=15) Mean±SD**	**Significance**
Proprioceptive Sense	Position Sense	pre	6.4±3.0	**p: .002***	5.0±2.8	**p: .001***
		post	8.6±2.1	**z:-3.0**	8.1±2.3	**z:-3.3**
	Passive Motion Sense	pre	6.8±1.8	**p: .002***	5.3±2.3	**p: .001***
		post	8.5±1.3	**z:-3.1**	8.4±1.4	**z:-3.3**
	Vibration Sense	pre	4.2±4.3	**p: .002***	2.5±2.2	**p: .001***
		post	6.4±4.5	**z:-3.1**	6.6±3.3	**z:-3.1**
Cortical Sense	Two-point Discrimination Sense	pre	6.9±2.8	**p: .000***	7.5±2.6	**p: .000***
		post	3.6±1.6	**t:6.5**	3.1±1.2	**t:7.7**
	Graphestesia	pre	3.1±1.4	**p: .000***	3.9±1.9	**p: .000***
		post	5.7±2.6	**t:-4.9**	6.8±1.8	**t:-14.22**
	Tactile Localization	pre	7.1±1.9	**p: .001***	6.3±2.3	**p: .001***
		post	8.8±1.0	**z:-3.2**	8.7±1.5	**z:-3.3**

Data expressed as mean ±standard deviation.

A Mc Nemar Test was used to examine group differences in regard to pre and post test of deep pain and tactile inattention. As per results, in electric stimulation group(EG) and sensory training group showed statistically significant difference in proprioceptive and cortical senses in Table 4.7. ($p \leq 0.05$). There were significant improvements in deep pain of both electric stimulation and sensory training group. Also there were improvements in tactile inattention of sensory training group.

Table 4.7. Comparison of deep pain and tactile inattention evaluation for intragroup variables between EG and SG

		Electric Stimulation % (n)	**p value**	**Sensory Training %(n)**	**p value**
Deep Pain	Positive	Pre: 53.3 (8)	**0.016***	Pre: 66.7 (10)	**0.008***
		Post:6.7 (1)		Post:13.3 (2)	
	Negative	Pre: 46.7 (7)		Pre: 33.3 (5)	
		Post:93.3 (14)		Post:86.7 (13)	
Tactile Inattention	Positive	Pre: 26.7 (4)	**0.050***	Pre:60 (9)	**0.031***
		Post:13.3 (2)		Post:20 (3)	
	Negative	Pre: 73.3 (11)		Pre:40 (6)	
		Post:86.7 (13)		Post:80 (12)	

Data expressed as mean ±standard deviation.

An independent-samples t test for parametric variables and mann-whitney u test for non-parametric variables used to compare of differences of proprioceptive and cortical senses between electric stimulation group and sensory training group in the wake of calculating intergroup differences before and after intervention in Table 4.8. The results showed that there were a statistically significant improvement in passive motion sense means in sensory training group (p≤0.05).

Table 4.8. Comparison of differences between pre and post evaluation results of the proprioceptive and cortical senses in intergroup variables

		Electric Stimulation (n=15) Mean±SD	**Sensory Training (n=15) Mean±SD**	**Significance**
Proprioceptive Sense	Δ Position Sense	2.2±1.5	3.0±1.1	p:0.10 u:-1.50
	Δ Passive Motion Sense	1.6±1.2	3.1±1.3	**p:0.02*** **u:-3.10**
	Δ Vibration Sense	2.2±2.2	4.1±2.9	p:0.27 u:-2.20
Cortical Sense	Δ Two-point Discrimination Sense	-33±1.9	-4.4±2.2	p:0.15 t:1.40
	Δ Graphestesia	2.6±2.0	2.9±0.7	p:0.55 t:-0.50
	Δ Tactile Localization	1.7±1.3	2.4±1.1	p:0.11 u:-1.50

Data expressed as mean ±standard deviation.

Chi-square test was used to compare the differences of deep pain and tactile inattention between electric stimulation group and sensory training group in the wake of calculating intergroup differences before and after intervention. The results showed that there were no statistically significant differences according to deep pain and tactile inattention between two groups.

Table 4.9. Comparison of differences between pre and post evaluation results of the deep pain and tactile ınattention evaluation in intergroup variables

		Electric Stimulation % (n)	**Sensory Training %(n)**	**λ^2**	**p value**
Δ Deep Pain	Recovery	46.7(7)	53.3(8)	0.13	0.715
	Same	53.3(8)	46.7(7)		
Δ Tactile Inattention	Recovery	13.3(2)	40(6)	2.72	0.090
	Same	86.7(13)	60(9)		

Data expressed as mean ±standard deviation.

5. DISCUSSION

The results of our study were compared with the effects of the sole of foot sensory education and electrical stimulation on proprioceptive and cortical senses in addition to neurodevelopmental treatment approaches in acute hemiplegic patients. We found positive effect on proprioceptive and cortical senses, Therefore, it was concluded that the sole of foot sensory training and electrical stimulation should be included in post-stroke physiotherapy and rehabilitation programs.

Sensory training is an active education including the training of deep and cortical senses, while electric stimulation is a passive treatment. While both active and passive therapy develop sensory impairment, it has not been proven that active physical therapy has a distinct advantage over passive.

Sensory disturbance is a very common problem after stroke. According to research, 50% of patients experience sensory impairment. This sensory disturbance prevents the patient from discovering the environment, leading to many problems that prevent the patient's daily life. (5) After stroke, balance problems and the risk of fall arise with the decrease in sensory input quality. (65) Therefore, it is necessary to contribute to the healing process in hemiplegia with the improvement of the senses. Most studies have shown recovery in superficial, proprioceptive and cortical sensations such as vibration, light touch, and two-point discrimination. (17,67,69)

In some studies, significant advances have been reported in upper limb treatments made using sensory training after a stroke. (17, 66, 67) Yekutiel et al. studied with hemiplegic patients with sensory deficit in the hand for two or more years after stroke. Before and after this period, sensation in the plegic hand was tested. On all sensory tests, the treated group showed significant gains. It is showed that somatosensory deficit can be alleviated even years after stroke and that for those with sensory deficit, rehabilitation for stroke patients should include sensory retraining. (17)

Byl et al. have applied motor and sensory studies in upper extremity in chronic hemiplegic patients into two group. As a result, there is an increase in upper extremity functions in both groups. This study provides evidence of significant functional improvement in the late post-stroke recovery period after sensory motor training. (66)

Smania et al. have made improvement in the somatic and motor control deficiencies at hand with cortical and subcortical pure sensory stroke patients using exercises aimed at recovering sensation and motor control especially in tactile discrimination and joint position sense in their study. (67) In our study, on the contrary of these studies, of the sensory training lower extremity sense was investigated in acute period and we found a significant progress in the sole of foot sensation as a result program.

We have seen that a similar topic about sensory training on the sole of foot after the stroke is very few. Morioka et al. applied sensation training for 10 days to the sole of foot in (hardness discrimination task). They used three different levels of rubber sponge in hardness (5, 10 and 15 mm thickness). Patients were asked determine the thickness of the rubber sponges while blindfoldedly 10 times. The treatment was performed in standing under the sole of foot daily for 10 days. This sensation training has been proven to have a positive effect on the balance of standing. (68)

On the other hand, Susan Hillier et al. examined three male stroke patients with superficial sensations and proprioception. The sensory education program was applied for 45 minutes each day and 3 days every week for 2 weeks. The program was designed to detect, locate and discriminate hemiparetic foot sensations, practice recognizing familiar surfaces and textiles applied to the foot, such as sandpaper and tiles. As a result of 2 weeks of sensory education on the sole of foot, light touch was developed and no significant progress was made in proprioception. (69) In our study, a significant improvement was observed in all proprioceptive and cortical senses in the sensory education group as a result of the sensory study performed in the same area.

There are different sensory education protocols applied to upper and lower extremities, mostly to upper extremities. De Jersey said that the senses and movement were engaged and that it would be treated with re-education. He used ice, vibration and different textures in his treatment program. (70) Lynch et al. used detection and localization of touch, hardness, texture and temperature discrimination. (71) Also, Carey et al. perform limb position discrimination to investigate effects of sensory training of chronic stroke patients. (72) Based on these studies, in the protocol we created, different sizes of sensory balls, rigit and soft object, ice, vibration, massage and different surfaces were used to create sensory input.

Luckie et al investigate experiences of people with stroke and lower limb sensation disorders. They found that sensory deficits are prevalent and permanent. Sensory deficits directly affect balance, gait, mobility and fall. Based on the fact that sensory disorder is common and affects functionality, we also conducted sensory training for patients with acute hemiplegia. (73)

In another similar study, Lynch and colleagues investigated the effect of sensation, postural control and gait on acute stroke patients who would use sensory training on the sole of foot after acute stroke. In postural control, timed gait, walking aid and in light touch of the feet, significant improvements were found. No significant effects on proprioception or amount of assistance needed to walk were observed. (71) Similarly, in our study, we studied the effects of sensory training on the sole of foot with acute stroke patients. However, on the contrary, we found a significant improvement in proprioceptive sensation.

Proprioception affects the perception of the position of the limb. As a result of the loss of this ability, patients get negative consequences for exploration objects, control of movement and rehabilitation of motor function. (74, 75, 76)

Smith and his colleagues evaluated acute hemiplegic patients in terms of proprioception and spatial negligence. In this study, a significant proprioception disorder was detected in 44% of patients. Diagnosing proprioception loss and recognizing the existence of negligence in stroke patients is essential for the clinician as this affects rehabilitation and may explain the failure of the patient to react to therapy. In their study, there was an improvement in proprioception on 87% of patients. (77)
In our own results, we can add sensory inputs to the treatment program for retreatment and improvement of motor function based on the increase in the proprioception.

Afferent sensory stimulus in the motor cortex triggers healing. Sullivan et al. indicated that the combination of electrical stimulation and motor stimulation provides sensory improvement for the function of the upper extremity. (20) Wu et al. found that electric sensory stimulation may enhance the paretic-hand function in chronic stroke and benefit of neurorehabilitative treatments and motor learning. (78)

Tyson et al. claimed that results provide initial evidence of potential of ' active TENS ' that is transcutaneous electrical nerve stimulation during everyday activities to benefit post-stroke physical function. Participants got better balance, mobility and plantarflexor joint position sense. (79)

While we use electrical stimulation for sensory recovery, chae and colleagues have only used it for motor healing and found it beneficial. Chae et al. a total of 15 sessions per day with electrical stimulation combined exercise therapy has proven to be more effective in patients with acute stroke compared to the placebo group on upper extremity motor recovery. (11)

Schuhfried et al investigate electrical stimulation to provide an overview of the clinical application of transcutaneous electrical stimulation in patients with upper motor neuron lesions. One form of electrical stimulation is a purely sensory stimulation that can cause triggering sensorimotor reorganization, muscle tone reduction and spasticity inhibitory effect. (80)

In our study, we found significant effects on the proprioception and cortical senses with sensory stimuli to the sole of the foot using electrical stimulation, as in similar studies. This shows us that we can make progress in the lower extremity functions by using electrocritical stimulation.

As far as we know, no studies published to investigate the comparison of the effects on the sole of foot sensory education and electrical stimulation on the sole of foot of proprioceptive and cortical senses in acute hemiplegic patients. When the result of our study that we compared the efficacy of two groups, were evaluated, there was a significant increase in all proprioceptive and cortical senses, while the advantage of the two groups was found only passive motion sense of sensory training group over electrical stimulation group.

In order to test sensory disturbances involving two-point discrimination, stereognosis, texture discrimination, tactile localization, and position sense, Kim and his colleagues studied acute hemiplegic patients. Sensory disturbances, such as stereognosis, texture discrimination, and tactile localization, were found more frequently (57 out of 67 patients). (81) In our study, we investigated position sense, passive motion sense, vibration sense, two-point discrimination sense, graphestesia, tactile localization, deep pain and tactile inattention and all of them progressed like as Kim’s study.

Esra Doğru investigate the effect of lower extremity sensory training on body control and upper extremity functions with stroke patients. She said that during the activity, information that goes from the environment to the central nervous system goes through the sole of foot and back of the thigh. The development of the sense of sole of foot and back of the thigh allows for better quality of activities that require reaching in the sitting position. As a result of the sensory training conducted in our study, we can suggest that the development of sole of foot sensation may have an effect on sitting balance. (82)

In a review study with Scahbrun et al., active and passive sense training after stroke was investigated. Electrical stimulation modalities that do not generate muscle contractions as passive training were wanted to be stimulated with surface electrodes and somatosensory areas. In active education, distinctive and localized sensations such as, sterognosis and proprioception were targeted. As a result of the study, it was found that there is a limited number of active education in the literature. (83) In our study, we investigate the comparison of active and passive sensory education on stroke patients to contribute to the literature. The result of the study shows that there are no significant effect on each other except position sense between two group.

In a study conducted abroad, most doctors and therapists have proven that they do not ignore sensory evaluation. They evaluate somatosensory loss after stroke on a regular basis. Somatosensory evaluation is clinically relevant to provide useful information for prognosis in somatosensory testing. (14)

6. CONCLUSION

The results of our planned study to compare the effects of sensory education and electrical stimulation on the sole of foot of proprioceptive senses as joint position sense, vibration sense, joint motion sense, deep pain and cortical senses as stereognosis, graphestesia, tactile localization, two-point discrimination in addition to neurodevelopmental treatment approaches in stroke patients are summarized.

As a result of the 15 sessions treatment, there was a significant increase in the sole of foot proprioceptive and cortical senses in both groups. However, when the two groups were compared, it was found that the sensory group was superior to the electrical stimulation group only in the sense of passive motion from the proprioceptive senses.

It is known that sensory education in stroke patients affects the functionality. Therefore it is concluded that the evaluation and treatment of the sole of senses should not be neglected in the rehabilitation programs of stroke patients.

In the future, we suggest to investigate if the sole of foot sensation training has a positive effect on functionality in stroke patients. In addition, the number of patients received in the study is limited. More patients should be included in the study and more studies should be conducted. Because of the fact that sensory education and electrical stimulation are not compared in the literature, our study is thought to contribute significantly to literature in this field.

REFERENCES

1) Bumin G, Ergun A, Uyanık M, Kayıhan H. Sağ ve Sol Hemiplejik Hastalarda Duyu, Algı ve Fonksiyonel Durumun Karşılaştırılması. *F.Ü. Sağ. Bil. Derg.* 2007;21 (5): 221 – 224.

2) Memiş S, Krespi Y, Durna Z, Tülek Z. Akut İnmeli Hastalarda Hemşirelik Bakımı Uygulama Rehberi. *İ.Ü.Basım ve Yayınevi Müd.* 2003;1-132.

3) Kumral E. Akut İskemik İnmenin Klinik Özellikleri. *Akut İskemik İnme*. 2002;24-42.

4) Young JA, Tolentino M. Neuroplasticity and Its Applications for Rehabilitation. *American Journal of Therapeutics* 2011;January 18(1): 70-80.

5) Carey LM. Somatosensory Loss After Stroke. *Crit Rev Phys Rehabil Med*. 1995;7:51-91.

6) Sterzi R. Hemianopia, Hemianesthesia and Hemiplegia After Right and Left Hemisphere Damage: A Hemispheric Difference. *J Neurol Neurosurg Psychiatry*. 1993;56:308-10.

7) Bardak AN, Ersoy S, Akcan Z, Kaya B, Dere Ç, Uysal E, Paker N. Önal A. Functional Outcome of Inpatient Stroke Rehabilitation. *Turk J Phys Med Rehab.* 2008; 54:17-21

8) Niam S, Cheung W, Sullivan PE, Kent S, Gu X. Balance and Physical Impairments After Stroke. *Arch Phys Med Rehabil.* 1999;80:1227-33.

9) Hsu AL, Tang PF, Jan MH. Analysis of Impairments Influencing Gait Velocity and Asymmetry of Hemiplegic Patients After Mild to Moderate Stroke. *Arch Phys Med Rehabil.* 2003;84:1185-93.

10) Nadeau S, Arsenault AB, Gravel D, Bourbonnais D. Analysis of the Clinical Factors Determining Natural And Maximal Gait Speeds in Adults with a Stroke. *Am J Phys Med Rehabil.* 1999;78:123-30.

11) Chae J, Bethoux F, Bohine T, Dobos L, Davis T, Friedl A. Neuromuscular Stimulation for Upper Extremity Motor and Functional Recovery in Acute Hemiplegia. *Stroke.*1998;29: 975–79.

12) Powell J, Pandyan AD, Granat M, Cameron M, Stott DJ. Electrical Stimulation of Wrist Extensors in Poststroke Hemiplegia. *Stroke.* 1999;30: 1384–89.

13) Bolognini N, Russo C, Edwards DJ. The Sensory Side of Post-Stroke Motor Rehabilitation. *Restorative Neurology and Neuroscience*. 2016;34(4), 571–586.

14) Winward CE, Halligan PW, Wade DT. Current Practice and Clinical Relevance of Somatosensory Assessment After Stroke. *Clinical Rehabilitation.* 1999;13(1), 48–55.

15) Peurala SH, Pitkänen K, Sivenius J, Tarkka IM. Cutaneous Electrical Stimulation May Enhance Sensorimotor Recovery in Chronic Stroke. *Clinical Rehabilitation.* 2002;16: 709–716.

16) Magnusson M, Johansson K, Johansson BB. Sensory Stimulation Promotes Normalization of Postural Control After Stroke. *American Heart Association.* 1994;25: 1176-1180.

17) Yekutiel M, Guttman E. A Controlled Trial of the Retraining of the Sensory Function of the Hand in Stroke Patients. *Journal of Neurology, Neurosurgery & Psychiatry.* 1993;56(3), 241–244.

18) Kimberley TJ, Lewis SM, Auerbach EJ, Dorsey LL, Lojovich JM, Carey JR. Electrical stimulation driving functional improvements and cortical changes in subjects with stroke. *Exp Brain Res.* 2014;154: 45060. 11.

19) Yozbatiran N, Donmez B, Kayak N, Bozan O. Electrical stimulation of wrist and fingers for sensory and functional recovery in acute hemiplegia. *Clin Rehabil*. 2006;20: 411. 12.

20) Sullivan JE, Hedman LD. A Home Program of Sensory and Neuromuscular Electrical Stimulation Integrated with Upper-Limb Task Practice in a Patient Who Is Stable After a Stroke. *Phys Ther*. 2004;84: 104554.

21) World Health Organization. Facts and Figures. The World Health Report (2003) - Shaping the Future. Available from: Erişim tarihi 2014. *http://www.who.int/entity/whr/2003/en/Facts_and_Figures-en.pdf.*

22) Chen JC, Liang CC, Shaw FZ. Facilitation of Sensory and Motor Recovery by Thermal Intervention for the Hemiplegic Upper Limb in Acute Stroke Patients: A Single-Blind Randomized Clinical Trial. *Stroke*. 2005;36(12), 2665–2669.

23) Yıldız D. Ischemic Stroke Awareness Among Primary Care Physicians. *Bakırköy Tıp Dergisi.* 2018;14:377-80.

24) Peker Ö, Beyazova M, Gökçe Y. Fonksiyonel Değerlendirme. *Fiziksel Tıp ve Rehabilitasyon, GüneşKitapevi*. 2000;Cilt 1. 642-656.

25) Aras DM, Çakcı A, Oğuz H, Dursun E, Dursun N. İnme Rehabilitasyonu. *Tıbbi Rehabilitasyon, Nobel Tıp Kitapevleri*. 2004;589-617.

26) Kumral E, Balkır K, Balkan S, Inme epidemiyolojisi. *Serebrovasküler Hastalıklar. Ankara; Güneş Kitabevi.* 2002;38-47.

27) Goldstein LB, Bushnell CD, Adams RJ, Chaturvedi S, Creager MA. Guidelines for the Primary Prevention of Stroke: A Guideline for Healthcare Professionals From the American Heart Association. *American Stroke Association*. 2011;42:517-84.

28) Kıyan S, Özsaraç M, Ersel M. Aksay E, Yürüktümen A, Musalar E, Çevrim O. Retrospective Analysis of 124 Acute Ischemic Stroke Patients Who Attended to The Emergency Department in One Year Period. *Akademik Acil Tıp Dergisi*. 2009;8:3

29) Çıgşar G, User NN. Analysis of Acute Stroke Patients Admitted to the Emergency Department. *Kafkas J Med Sci* 2015;5(1):6–12.

30) Kabakcı G, Abacı A, Ertaş FS, Özerkan F, Erol Ç, Oto A. The Risk for Stroke and Differences Among Geographical Regions Regarding This Risk in Hypertensive Patients in Turkey: A Hospital-Based, Cross-Sectional, Epidemiological Questionnaire. *Turk Kardiyol Dern Ars*. 2006;34(7): 395-405.

31)) Adams HP, Bendixen BH, Kappelle LJ, Biller J, Love BB. Gordon DL. Classification of Subtype of Acute İschemic Stroke. Definitions For Use in a Multicenter Clinical Trial. TOAST. Trial of Org 10172 in Acute Stroke Treatment. *Stroke*. 1993;24:35-4.

32) Erdemoğlu AK, Sevgi EB. Laküner İnfarktlar Ve Laküner Sendromlar. *Journal of Turkish Cerebrovascular Diseases*. 2011;17:2; 37-48

33) Caceres JA, Goldstein JN. Intracranial Hemorrhage. *Emergency Medicine Clinics of North America*. 2012;30(3), 771–794.

34) Kopitnik TA, Samson DS. Management of Subarachnoid Haemorrhage. *Journal of Neurology, Neurosurgery & Psychiatry*. 1993;56(9), 947–959.

35) Ham AW. Histology (7th Ed.). *Philadelphia: J.B. Lippincott Company.* 1974.

36) Bahar SZ, Aktin E. Nöroloji (2.baskı) İstanbul*; Güneş Kitabevi* 2015;126-130.

37) Walker HK, Hall WD, Hurst JW. Clinical Methods: The History, Physical, and Laboratory Examinations*. 3rd edition. Boston: Butterworths.* 1990;225-228.

38) Webb WG. Neurosensory Organization, Neurology for the Speech-Language Pathologist*. (Sixth Edition)*. 2017;67-70.

39) Shenington CS. On The Proprioceptive System, Especially in Its Reflex Aspects. *Brain.* 1906;29:467-82.

40) Lephart SM, Pincivero DM, Giraido JL, Fu FH. The Role of Proprioception in the Management and Rehabilitation of Athletic Injuries. *The American Journal of Sports Medicine.* 1997;25(1), 130–137.

41) Houglum PA. Therapeutic Exercise for Athletic Injuries. *Human Kinetics, Champaign, Illinois*. 2001;2 (2): 78–79.

42) Wilk KE, Macrina LC, Arrigo C. Shoulder Rehabilitation. *Physical Rehabilitation of the Injured Athlete. (Fourth Edition*). 2012;190-231

43) Lorenz MD, Coates JR, Kent M. Neurologic History, Neuroanatomy, and Neurologic Examination. *Handbook of Veterinary Neurology (Fifth Edition*). 2011;2-36.

44) Dover G, Powers ME. Reliability of Joint Position Sense and Force-Reproduction Measures During Internal and External Rotation of the Shoulder. *Journal of Athletic Training*. 2003;38(4):304–310.

45) Jones LA. The Perception of Force and Weight: Theory and Research. *Psychol Bull.* 1986;100:29–42.

46) Irving JB. Stereognosis. *Res Medica.* 1968. Volume VI, Number 2.

47) Donnelly K. Graphesthesia. *Encyclopedia of Clinical Neuropsychology.* 2011;1174-1175.

48) Rowin J, Meriggioli MN. *Proprioception, Touch, and Vibratory Sensation. Textbook of Clinical Neurology*. 2007;343–361.

49) Yoshioka T, Dillon MR, Beck GC, Rapp B, Landau B. *Tactile Localization on Digits and Hand Psychological Science.* 2013;24(9),1653–63.

50) Prescott SA, Ratté S. Somatosensation and Pain. *Conn's Translational Neuroscience.* 2017;517-539

51) Lincoln N, Jackson J, Adams S. Reliability and Revision of the Nottingham Sensory Assessment for Stroke Patients. *Physiotherapy*. 1998;84(8), 358–365.

52) Fox VD. Cutaneous Stimulation: Effects on Selected Test of Perceptions. *Am J Occup Ther.* 1964;18,53-55.

53) Kim JH, Greenspan JD, Coghill RC, Ohara S, Lenz FA. Lesions Limited to the Human Thalamic Principal Somatosensory Nucleus (Ventral Caudal) Are Associated with Loss of Cold Sensations and Central Pain. *Journal of Neuroscience.* 2007;27(18), 4995–5004.

54) Kim JS, Bae YH. Pure or Predominant Sensory Stroke Due to Brain Stem Lesion. *Stroke*. 1997;28:1761–1764.

55) Cole L, Kramer PR. Seeing, Hearing, Tasting, Smelling, and Touching. *Human Physiology, Biochemistry and Basic Medicine*. 2016;101–104.

56) Bagheri SC. Dentoalveolar Surgery. *Clinical Review of Oral and Maxillofacial Surgery* 2014;119–139.

57) Flaten MA. Placebo Responses, Antagonistic Responses, and Homeostasis. *Placebo and Pain*. 2013;103–113

58) Keane M, O'Tool M. Miller-Keane Encyclopedia and Dictionary of Medicine, Nursing and Allied Health, Seventh Edition. 2003;38-42.

59) Johnson M. Transcutaneous Electrical Nerve Stimulation (TENS) in The Management of Labour Pain: The Experience of Over Ten Thousand Women. *British Journal of Midwifery*. 1997;5: 400–405.

60) Johnson M. Transcutaneous Electrical Nerve Stimulation: Mechanisms, Clinical Application and Evidence. *British Journal of Pain*. 2015. Vo l. 1, No. 1.

61) Tulgar M, Arslan A. Kalkan E. Ağrı ve Nörostimülasyon. *Van Tıp Dergisi*. 1998. Cilt: 5, Sayı: 4.

62) Tashani O, Johnson M. Transcutaneous Electrical Nerve Stimulation (TENS). A Possible Aid for Pain Relief in Developing Countries? *Libyan Journal of Medicine*. 2008;4(2), 77–83.

63) Sluka KA, Deacon M, Stibal A. Spinal Blockade of Opioid Receptors Prevents The Analgesia Produced by TENS in Arthritic Rats. J *Pharmacol Exp Ther*. 1999;289,840–846.

64) Sluka KA, Chandran P. Enhanced Reduction in Hyperalgesia by Combined Administration of Clonidine and TENS. *Pain*. 2002;100,183–190.

65) Smania N, Picelli A, Gandolfi M, Fiaschi A, Tinazzi M. Rehabilitation of Sensorimotor Integration Deficits in Balance Impairment of Patients with Stroke Hemiparesis: a Before/After Pilot Study. *Neurological Sciences*. 2008;29(5), 313–319.

66) Byl N, Roderick J, Mohamed O, Hanny M, Kotler J, Smith A, Tang M, Abrams G. Effectiveness of Sensory and Motor Rehabilitation of the Upper Limb Following the Principles of Neuroplasticity: Patients Stable Poststroke. *Neurorehabilitation and Neural Repair.* 2003;17(3), 176–191.

67) Smania N, Montagnana B, Faccioli S, Fiaschi A, Aglioti SM. Rehabilitation Of Somatic Sensation and Related Deficit of Motor Control in Patients With Pure Sensory Stroke. *Physical Medicine and Rehabilitation.* 2003;84(11), 1692–1702.

68) Morioka S, Yagi F. Effects of Perceptual Learning Exercises on Standing Balance Using a Hardness Discrimination Task in Hemiplegic Patients Following Stroke: A Randomized Controlled Pilot Trial. *Clinical Rehabilitation*. 2003;17(6), 600–607.

69) Hillier S, Dunsford A. A pilot Study Of Sensory Retraining for The Hemiparetic Foot Post-Stroke. *International Journal Of Rehabilitation Research.* 2006;29(3), 237–242.

70) De Jersey MC. Report On A Sensory Programme for Patients with Sensory Deficits. *Australian Journal Of Physiotherapy*. 1979;25(4), 165–170.

71) Lynch EA, Hillier SL, Stiller K, Campanella RR, Fisher PH. Sensory Retraining of the Lower Limb After Acute Stroke: A Randomized Controlled Pilot Trial. *Archives of Physical Medicine and Rehabilitation*. 2007;88(9), 1101–1107.

72) Carey LM, Matyas TA, Oke LE. Sensory Loss in Stroke Patients: Effective Training of Tactile and Proprioceptive Discrimination. *Arch Phys Med Rehabil.* 1993;74(6):602-11.

73) Luckie H, Hollands K, Williamson T, Nester C, Williams A. Comfortably numb? Experiences of people with stroke and lower limb sensation deficits: impact and solutions. *Disability and Rehabilitation: Assistive Technology*. 2019;1–8.

74) Kusoffsky A, Wadell I. Nilsson BY. The Relationship between Sensory Impairment And Motor Recovery in Patients with Hemiplegia. *Scand J. Rehabil Med.* 1982;14(1):27-32.

75) Loo CK, Hall LA, McCloskey DI, Rowe MJ. Proprioceptive Contributions to Tactile Identification of Figures: Dependence on Figure Size. *Behav Brain Res.* 1983;7(3):383-6.

76) Jeanncrod M. The Neural and Behavioural Organization of Goal-Directed Movements. *Oxford: Clarendon.* 1988;171-208.

77) Smith DL, Akhtar AJ, Garraway WM. Proprioception And Spatial Neglect After Stroke. *Age And Ageing.* 1983;12(1), 63–69.

78) Wu CW, Seo HJ, Cohen LG. Influence of Electric Somatosensory Stimulation on Paretic-Hand Function in Chronic Stroke. *Arch Phys Med Rehabil.* 2006;Vol 87.

79) Tyson SF, Sadeghi-Demneh E, Nester CJ. The effects of Transcutaneous Electrical Nerve Stimulation on Strength, Proprioception, Balance and Mobility in People with Stroke: A Randomized Controlled Cross-Over Trial. *Clinical Rehabilitation.* 2013;27(9) 785–791.

80) Schuhfried O, Crevenna R, Fialka-Moser V, Paternostro-Sluga T. In Patients with Central Nervous System Lesions: An Educational Review. *Journal of Rehabilitation Medicine.* 2012;44(2), 99–105.

81) Kim JS, Choi-Kwon S. Discriminative Sensory Dysfunction After Unilateral Stroke. *Stroke.* 1996;677-82.

82) Dogru E. İnme Hastalarındauyluk Arkası Duyu Eğitiminin Gövde Kontrolü ve Üst Ekstremite Fonksiyonlarına Etkisi. Hacettepe Üniversitesi Sağlık Bilimleri Enstitüsü Doktora Tezi. 2014.

83) Schabrun S, Hillier S. Evidence for The Retraining of Sensation After Stroke: A Systematic Review. *Clinical Rehabilitation*. 2009;23(1), 27–39.

84) Gilman S. Joint position sense and vibration sense: anatomical organisation and assessment. *Journal of Neurology, Neurosurgery & Psychiatry*. 2002; 73(5), 473–477.

85) Takahara M, Fujiwara Y, Sakamoto F, Katakami N, Matsuoka T, Kaneto H, Shimomura I. Assessment Of Vibratory Sensation With A Tuning Fork At Different Sites In Japanese Patients With Diabetes Mellitus. *J Diabetes Investig.* 2014; 5(1): 90–93.

86) Won S, Kim H, KIM E, KIM K. Two-point discrimination values vary depending on test site, sex and test modality in the orofacial region: a preliminary study. *Journal of Applied Oral Science.* 2017;25(4), 427–435.

87) Santa Maria M, Pinkston J, Browndyke J, Gouvier W. (1997). Fine Tuning the Graphesthesia Assessment: One Stroke Versus Two. Applied Neuropsychology, 4(2), 127–129.

88) Yoshioka T, Dillon M, Beck G, Rapp B, Landau B. Tactile Localization on Digits and Hand. *Psychological Science*. 2013;24(9), 1653–1663.

APPENDIX 1. INFORMED WRITTEN CONSENT

T.C.YEDİTEPE ÜNİVERSİTESİ

Bu anket Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü Fizyoterapi ve Rehabilitasyon Anabilim Dalı, Yüksek Lisans Tezi için hazırlanan **"Akut Hemipleji Tanılı Hastalarda Ayak Tabanı Duyu Eğitmi ve Elektrik Stimulasyonun Proprioseptif ve Kortikal Duyular Üzerine Etkisinin Karşılaştırılması"** adlı araştırma kapsamında kullanılmaktadır. Bu çalışmanın amacı hemipleji tanısı almış bireylerde, duyu eğitimi veya elektrik stümilasyonla kombine edilmiş nörogelişimsel fizyoterapi programının ayak tabanı duyusu üzerine etkilerinin karşılaştırılmasıdır. Çalışmaya akut hemipleji tanısı almış 40 hasta dahil edilecek, fizyoterapi seansları haftanın 5 günü toplamda 15 seans olmak üzere 20 dakika sürecektir.

Araştırma ile ilgili sizden doldurmanızı istediğimiz formları doğru bir şekilde doldurmanız ve herhangi bir şikayetiniz ya da rahatsızlığınız olduğunda bize bildirmeniz gerekmektedir. İstediğiniz zaman çalışma dışına çıkma hakkınız olduğunu bilmenizi isteriz. Bu araştırma kapsamında uygulanacak olan uygulamalarda herhangi bir risk bulunmamakta ve yapılacak hiçbir uygulama size zarar vermeyecektir. Bu araştırma dahilinde sizden herhangi bir ücret talep edilmemektedir. Bu araştırmada yer almanız nedeniyle size hiçbir ödeme yapılmayacaktır. Kişisel bilgileriniz herhangi bir amaçla, kurum yöneticileri veya üçüncü kişilerle paylaşılmayacaktır.

Katılımınız için teşekkür ederiz.

Danışman Öğretim Üyesi: Doç. Dr. Rasmi MUAMMER

Araştırmacı: Fzt. Cansu HAYIROĞLU (Araştırma süresince 24 saat ulaşılabilecek kişi)

Akut Hemipleji Tanılı Hastalarda Ayak Tabanı Duyu Eğitmi ve Elektrik Stimulasyonun Proprioseptif ve Kortikal Duyular Üzerine Etkisinin Karşılaştırılması isimli çalışmada katılımcıya/gönüllüye verilmesi gereken bilgileri okudum ve katılmam istenen çalışmanın kapsamını ve amacını, gönüllü olarak üzerime düşen sorumlulukları tamamen anladım. **Çalışma hakkında yazılı ve sözlü açıklama adı belirtilen araştırmacı tarafından yapıldı.** Bu çalışmayı istediğim zaman ve herhangi bir neden belirtmek zorunda kalmadan bırakabileceğimi ve bıraktığım takdirde herhangi bir olumsuzluk ile karşılaşmayacağımı anladım.

Bu koşullarda söz konusu araştırmaya kendi isteğimle, hiçbir baskı ve zorlama olmaksızın katılmayı kabul ediyorum.

Gönüllünün Adı Soyadı/ İmzası:

Açıklama Yapan Kişinin Adı Soyadı/ İmzası: Cansu Hayıroğlu

APPENDIX 2. STRUCTURED QUESTIONNAIRE

Yeditepe Üniversitesi

Sağlık Bilimleri Enstitüsü

Fizyoterapi ve Rehabilitasyon Anabilim Dalı

Adı:
Soyadı:
Cinsiyet:
Yaş:
Boy:
Kilo:
BMI:
Özgeçmiş:
Medeni Durumu: Evli □ Bekar □ Dul □ Boşanmış □
Eğitim Seviyesi: Okur-yazar değil □ İlköğretim □ Lise □ Üniversite □ Lisans üstü □
Dominant taraf: Sağ □ Sol □
Hemiplejik Taraf ve Etkilenen Bölge: Sağ □ Sol □ Bölge:
Olay Tarihi:
Daha önce inme geçirildi mi ? Evet □ Hayır □ Olay Tarihi:
Daha önce rehabilitasyon görüldü mü? Evet □ Hayır □ Süresi:
Son 6 ay içerisinde medikal operasyon geçirildi mi? Evet □ Hayır □ Bölge ve İşlem:
Kullandığı cihaz var mı? Evet □ Hayır □ Cihaz ismi:

Mini Mental Skoru:

Vas Skalası:

Duyu Değerlendirmesi:

1-Derin Duyu (Proprioseptif Duyu)

a- Pozisyon duyusu
İlk: Son:

b- Pasif hareket duyusu
İlk: Son:

c- Vibrasyon duyusu
İlk: Son:

d- Derin ağrı
İlk: Son:

2-Kortikal Duyu

a- İki nokta ayırımı
İlk: Son:

b- Grafestezi
İlk: Son:

c- Taktil lokalizasyon
İlk: Son:

d- Taktil inatansiyon (Sönme fenomeni)
İlk: Son:

APPENDIX 3. MINI MENTAL TEST

STANDARDİZE MİNİ MENTAL TEST

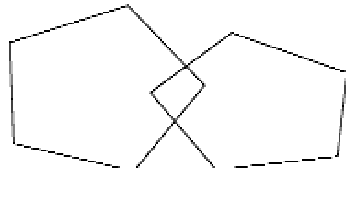
YÖNELİM (Toplam puan 10)
Hangi yıl içindeyiz . . . . ( )
Hangi mevsimdeyiz . . . . ( )
Hangi aydayız . . . . ( )
Bu gün ayın kaçı . . . . ( )
Hangi gündeyiz . . . . ( )
Hangi ülkede yaşıyoruz . . . . ( )
Şu an hangi şehirde bulunmaktasınız. . . . . ( )
Şu an bulunduğunuz semt neresidir . . . . ( )
Şu an bulunduğunuz bina neresidir . . . . ( )
Şu an bu binada kaçıncı kattasınız. . . . . ( )

KAYIT HAFIZASI (Toplam puan 3)
Size birazdan söyleyeceğim üç ismi dikkatlice dinleyip ben bitirdikten sonra tekrarlayın (Masa, Bayrak, Elbise) (20 sn süre tanınır) Her doğru isim 1 puan . . . . ( )

DİKKAT VE HESAP YAPMA (Toplam puan 5)
100'den geriye doğru 7 çıkartarak gidin. Dur deyinceye kadar devam edin.
Her doğru işlem 1 puan. (100, 93, 86, 79, 72, 65) . . . . ( )

HATIRLAMA (Toplam puan 3)
Yukarıda tekrar ettiğiniz kelimeleri hatırlıyor musunuz? Hatırladıklarınızı söyleyin.
(Masa, Bayrak, Elbise). . . . . ( )

LİSAN (Toplam puan 9)
a) Bu gördüğünüz nesnelerin isimleri nedir? (saat, kalem) 2 puan (20 sn tut) . . . . ( )
b) Şimdi size söyleyeceğim cümleyi dikkatle dinleyin ve ben bitirdikten sonra tekrar edin.
"Eğer ve fakat istemiyorum" (10 sn tut) 1 puan . . . . ( )
c) Şimdi sizden bir şey yapmanızı isteyeceğim, beni dikkatle dinleyin ve söylediğimi yapın.
"Masada duran kâğıdı sağ/sol elinizle alın, iki elinizle ikiye katlayın ve yere bırakın lütfen"
Toplam puan 3, süre 30 sn, her bir doğru işlem 1 puan . . . . ( )
d) Şimdi size bir cümle vereceğim. Okuyun ve yazıda söylenen şeyi yapın. (1 puan)
"GÖZLERİNİZİ KAPATIN" (arka sayfada) . . . . ( )
e) Şimdi vereceğim kâğıda aklınıza gelen anlamlı bir cümleyi yazın. (1 puan) . . . . ( )
f) Size göstereceğim şeklin aynısını çizin. (arka sayfada) (1 puan) . . . . ( )



APPENDIX 4. ETHICAL COMMITTEE APPROVAL

T.C. YEDİTEPE ÜNİVERSİTESİ

Sayı : 37068608-6100-15-1551 **04/10/2018**
Konu: Klinik Araştırmalar
Etik kurul Başvurusu hk.

İlgili Makama (Cansu Hayıroğlu)

Yeditepe Üniversitesi Fizyoterapi ve Rehabilitasyon Anabilim Dalı Doç. Dr. Rasmi Muammer'in sorumlu olduğu **"Akut Hemipleji Tanılı Hastalarda Ayak Tabanı Duyu Eğitimi ve Elektrik Stimulasyonun Proprioseptif ve Kortikal Duyular Üzerine Etkisinin Karşılaştırılması"** isimli araştırma projesine ait Klinik Araştırmalar Etik Kurulu (KAEK) Başvuru Dosyası (**1527** kayıt Numaralı KAEK Başvuru Dosyası), Yeditepe Üniversitesi Klinik Araştırmalar Etik Kurulu tarafından **03.10.2018** tarihli toplantıda incelenmiştir.

Kurul tarafından yapılan inceleme sonucu, yukarıdaki isimi belirtilen çalışmanın yapılmasının etik ve bilimsel açıdan uygun olduğuna karar verilmiştir (**KAEK Karar No: 907**).

Prof. Dr. Turgay ÇELİK
Yeditepe Üniversitesi
Klinik Araştırmalar Etik Kurulu Başkanı

Yeditepe Üniversitesi 26 Ağustos Yerleşimi, İnönü Mahallesi Kayışdağı Caddesi 34755 Ataşehir / İstanbul
T. 0216 578 00 00 www.yeditepe.edu.tr F. 0216 578 02 99

CURRICULUM VITAE

Kişisel Bilgiler

Adı	Cansu	**Soyadı**	Hayıroğlu
Doğum Yeri		**Doğum Tarihi**	
Uyruğu		**TC Kimlik No**	
E-mail		**Tel**	

Öğrenim Durumu

Derece	Alan	Mezun Olduğu Kurumun Adı	Mezuniyet Yılı
Doktora			
Yüksek Lisans	FTR	Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü	2019
Lisans	FTR	Yeditepe Üniversitesi Sağlık Bilimleri Fakültesi	2015
Lise	Sayısal	Beşiktaş Atatürk Anadolu Lisesi	2010

Başarılmış birden fazla sınav varsa(KPDS, ÜDS, TOEFL; EELTS vs), tüm sonuçlar yazılmalıdır

Bildiği Yabancı Dilleri	Yabancı Dil Sınav Notu (#)
İngilizce	69

İş Deneyimi (Sondan geçmişe doğru sıralayın)

Görevi	Kurum	Süre (Yıl - Yıl)
Fizyoterapist	Eksen Sağlık	2015-

Bilgisayar Bilgisi

Program	Kullanma becerisi

*Çok iyi, iyi, orta, zayıf olarak değerlendirin

Bilimsel Çalışmaları

SCI, SSCI, AHCI indekslerine giren dergilerde yayınlanan makaleler

Diğer dergilerde yayınlanan makaleler

Uluslararası bilimsel toplantılarda sunulan ve bildiri kitabında (*Proceedings*) basılan bildiriler

Hakemli konferans/sempozyumların bildiri kitaplarında yer alan yayınlar
