International Journal of Health Sciences and Research
www.ijhsr.org ISSN: 2249-9571

Original Research Article

Effect of Transcutaneous Electrical Nerve Stimulation on Knee Joint Proprioception - A Cross Sectional Study in Healthy Adults

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ABSTRACT

Background: The ability to identify the placement of a joint in space even when with his/her vision is obstructed with minimal external cues is Joint position sense (JPS). Transcutaneous Electrical Nerve Stimulation (TENS) is a method where electric current is applied to the skin resulting in a large recruitment of sensory nerve fibres and mechanoreceptors.
Methodology: 200 young adults participating in the study were shown two Knee flexion angles (30^0) and (60^0) in weight bearing and non weight bearing position for the dominant leg. These angles were repeated and recorded when blindfolded and again after application of 30 minutes high frequency TENS.
Results: There was statistically significant difference noted (p=0.000) in weight bearing position only for 30^0knee flexion angle post TENS while the response for knee angles in non weight bearing position was statistically significant (p=0.00) for both $30^0$and 60^0 post TENS.
Conclusion: The application of TENS increases the joint position sense and proprioception of knee flexion angles of 30^0 and non weight bearing both $30^0$and 60^0 flexion angles. Non weight bearing position is the ideal method to improve knee joint position sense and thus proprioception.

Keywords: TENS, joint position sense, proprioception, functional knee angles, Knee Osteoarthritis, young adult.

INTRODUCTION

The automatic movement perception and spatial alignment arising from stimuli within the body is Proprioception. [1] The integration of afferent signals arising from the proprioceptive receptors (vestibular organs, visual perceptions and cutaneous receptors), due to internal and external stimuli influence the knee joint stability and balance. [2] Joint position sense (JPS) is one of the main components of proprioception which measures the accuracy of joint angle replication. This is measured by assessing an individual's ability to detect an external motion or by repositioning the joint to a prearranged position without the visual assistance. [3,4] Stochastic resonance in the form of electrical resonance alters the neuronic trans membrane potentials improving balance and proprioception in healthy older adults by Gravelle et al. [5] A similar study done by Dhruv et al suggested that functional impairments related to sensory loss on account of aging can be overcome by electrical stimulations. [6]

Transcutaneous electrical nerve stimulation (TENS) a modality commonly used for pain relief in physiotherapy is a non invasive technique with negligible adverse effects. It is efficacious, ingenuous and inexpensive equipment which stimulates the skin on application of electrical current. [7] A large number of mechanoreceptors and sensory fibres are recruited when stimulated by TENS at various frequencies, intensities and durations. Proprioceptors being specialised mechanoreceptors, relay continuous detailed knowledge about the positions of the various body parts to the cortex, aiding in their spatial position. [7,8] High frequency TENS when applied to the lower limb had a positive influence over the postural sway in a study done by Dickstein et al. They concluded that electrical stimulations decrease the mechanoreceptor thresholds and thus improve proprioception. [9,10]

On account of its perceptible stimulation TENS is more acceptable among subjects than stochastic resonance. Thus, our study is aimed to study the effect of high frequency TENS on joint position sense on normal healthy individuals.

METHODOLOGY

Out of 410 students, 200 normal healthy students within the age group 18-24 years without any lower limb injury in the past one year were randomly recruited following an approval from the Institutional Review Board. After an informed consent, the demographic data of the subjects were recorded.

As recent evidence proves that limb dominance affects the performance of joint position sense, the lower limb dominance was determined using the kicking football test. [11] The dominant limb was then selected for the intervention.

The goniometer was then strapped to the dominant lower limb with the fulcrum marked at the lateral epicondyle of the femur. The knee flexion angle of 30 degrees and 60 degrees in weight bearing (standing) and non weight bearing (prone lying) position was demonstrated to the subjects. They were then told to duplicate the same angles in the weight bearing and non weight bearing positions. This was again repeated with a blind fold. The two angles reproduced were measured in both weight bearing and non weight bearing positions with blind folds.

High frequency TENS of frequency 100 Hz was applied for 30 minutes to the medial and lateral epicondyle of the femur in the dominant leg. The subjects were then told to repeat knee flexion angles 30 degrees and 60 degrees in the weight bearing and non weight bearing positions. The angles recorded thus were analysed for absolute errors.

Statistical analysis was performed using SPSS version 19. Normality distribution was assessed using Shapiro Wilk test. Descriptive statistics were analysed. The mean of absolute errors in knee flexion angle (30 degrees and 60 degrees) before and after electrical stimulation by TENS was measured using Students' paired t test.

RESULTS

Table 1: Descriptive Statistics

Category	Values
Age (n=200)	Mean ± Standard Deviation = 21.23±1.83 years.
Gender (n=200)	Male –46.5% (n=93)
	Females – 53.5% (n=107)
Lower limb Dominance (n=200)	Right – 93% (n=186)
	Left –7% (n=14)

Table 2: The comparison of knee flexion angles (absolute errors) in weight bearing position

	Pre TENS	Post TENS	p value	t value
Weight bearing Position 30 degrees	5.60±2.92	2.81±2.39	0.000	10.093
Weight bearing Position 60 degrees	3.51±1.94	3.02±1.91	0.14	2.470

Inference: Knee flexion angles absolute errors in weight bearing position for both 30 degrees and 60 degrees reduced post TENS. The difference noted in the weight bearing position for 30 degrees is statistically significant.

Table 3: The comparison of knee flexion angles (absolute errors) in non weight bearing position

	Pre TENS	Post TENS	p value	t value
Non weight bearing Position 30 degrees	4.14±2.28	2.29±1.74	0.000	7.942
Non weight bearing Position 60 degrees	4.49±2.86	3.12±1.97	0.000	5.759

Inference: Knee flexion angles absolute errors in non weight bearing position for both 30 degrees and 60 degrees reduced post TENS and statistically significant.

DISCUSSION

Both in movement (kinesthesia) and in inert state (static limb position sense), every individual is aware of the position of their limbs. [1] This ability is proprioception. Proprioception can be described as: [2]

a) Position sense - awareness about the positions of one's own limbs and their orientation with respect to one another.
b) Movement Sense - the ability to comprehend both direction and velocity of the movement.
c) Force Sense - the ability to determine the amount of muscular force required to move a part or to maintain the limb position against a greater force.

A normal healthy knee relies on both static and dynamic stabilizers for support. The capsule-ligamentous structures mainly involved in stability provide somatosensory inputs by detecting joint positions and motions. These afferents are relayed directly to the reflex and cortical pathways and thus, mediates muscle reactivity completing the mechanism of proprioception. [1,2]

Our study was designed to explore the effect of TENS in improving proprioception. The repositioning errors were used as criterion for determining proprioception with respect to Joint Position sense. The results indicate that conventional TENS improves proprioception with respect to joint position sense.

Our results confirmed that repositioning error on a dynamic position sense task changes with TENS application. The findings of this study demonstrated that the mean of joint repositioning error in both 30 and 60 degrees reduced significantly after applying sensory electrical stimulation. This is comparable with the study conducted by Collins et al, who also observed that application of sensory electrical stimulation improved JPS. [12] Gravelle et al also noticed significant improvement in the somatosensory system and also balance in elder individuals on account of electric stimulation which was due to enhancement of proprioception. They attributed this augmentation to changes in the receptor transmembrane potentials generated on account of electrical stimulation. [5]

Another study by Birmingham et al noted that poor proprioceptive ability was greatly enhanced on electrical stimulation. They attributed this to increased afferent input from articular, muscular and cutaneous regions on account of stimulation, thus increasing the knee JPS. This mechanism of increased input was due to stimulation of cutaneous receptors, muscle spindle etc. located in the Anterior Cruciate Ligament, thus, increasing the proprioceptive abilities. [13,14]

High TENS application for 30 minutes increased the knee joint proprioception as seen in tables 2 and 3. This is probably due to stimulation of proprioceptors at the knee as corroborated by the above researchers. The absolute errors have reduced in both weight bearing and non weight bearing positions the non weight bearing position, however, demonstrated improvement in both 30 degrees and 60 degrees unlike the weight bearing position. Studies demonstrated that the non weight bearing position is ideal for measuring and training proprioception especially at the knee as it is devoid of movement and resistive forces from other joints. The angles reproduced by the subjects are more accurate in comparison to the weight bearing positions. [15]

30 degree of knee flexion angle was chosen to stimulate the position of knee soon after foot contact during the early stance phase of gait cycle. 60 degree of knee flexion is the normal angle of flexion of normal individuals for any stance and swing phase of a gait cycle. [16,17]

Active limb movement is potentially unavoidable in the weight bearing positions due to postural sway whereas the non weight bearing position does not require the body to maintain stability or balance. [18] The individual can focus completely on reproducing the test angles and this reduces errors. The errors were further minimized post TENS application due to stimulation of afferent fibres and increase in the somatosensory input channels. As observed in the results, TENS affects the proprioception in both positions and increase the sensitivity of the proprioceptors. It may be more beneficial when applied to subjects with proprioceptive deficits.

CONCLUSION

There was significant difference in the Joint Position Sense observed before and after TENS treatment. Conventional TENS with sensory threshold amplitude seems to have positive impact on proprioception sense in the knee joint. Non weight bearing position is mainly suited for proprioceptive training in the knee. Future work is necessary to determine if applying different types of TENS with different amplitudes will improve knee proprioception and also in larger populations with proprioceptive defects.

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How to cite this article: Krishnan V, Goswami S. Effect of transcutaneous electrical nerve stimulation on knee joint proprioception - a cross sectional study in healthy adults. Int J Health Sci Res. 2018; 8(8):171-175.

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