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Research Article

EFFECT OF LOW INTENSITY TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION (TENS) ON VASTUS MEDIALIS OBLIQUES MUSCLE ACTIVATION FOR REDUCTION IN PAIN AND IMPROVEMENT IN FUNCTION IN PATIENTS WITH CHRONIC OSTEOARTHRITIS OF KNEE JOINT

Mamta Shetty*[1], Rucha Pradhan[2], Sidra Shaikh[3], Trishala Singh[4], Trupti Shetty[5] and Sneha Venkatraman[6]

MGM School of Physiotherapy, MGM Institute of Health Sciences, Navi Mumbai, Maharashtra, India

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ABSTRACT

Background: This study aims to evaluate effects of low intensity TENS with exercises on Vastus medialis obliques activation for osteoarthritis knee. **Methodology:** The study comprised of 38 participants with chronic osteoarthritis knee (19 in each group) in the age group of 50-70 years as per ACR diagnostic criteria. Group A received conventional exercises. Group B received TENS on Vastus Medialis Obliques muscle additionally. They were assessed using the NRS, Modified WOMAC, Bergs Balance Scale and 30 Second Chair Stand Test. **Results:** Intra group analysis reported significant reduction in pain($p=0.00$) level(on NRS- 63.6% in group A and 39.6% in group B; on WOMAC- 72.4% in group A and 36.6% in group B), increase in function by 56.4% in group A and 33% in group B($p=0.00$), and improvement in strength by 35% in group A and 0.2% in group B($p=0.00$). No significant improvement was noted on inter group comparison in pain ($p= 0.086$), function ($p= 0.066$) and strength ($p=0.190$) post 12 weeks of intervention. **Conclusion:** Findings from present study report application of Low Intensity TENS for Vastus Medialis Obliques muscle activation along with exercise versus conventional exercises demonstrated no significant difference on chronic osteoarthritis knee patients for pain, function and strength.

INTRODUCTION

Osteoarthritis is defined as a degenerative, non-inflammatory joint disease characterized by destruction of articular cartilage and formation of osteophytes at joint surface and margins.[3] According to National health portal, prevalence of osteoarthritis in India is 22%- 39% and about 70% of population in India, above the age of 65 years have radiological evidence of osteoarthritis.[3,10] Risk factors for developing knee osteoarthritis are advancing age, genetic susceptibility, obesity, female gender, repetitive knee trauma, muscle weakness, joint laxity, mechanical forces, prolonged kneeling, prolonged squatting and meniscal injuries.[5,10] Osteoarthritis of knee is diagnosed using the ACR clinical classification criteria.[6,7] The presence of knee pain along with at least three of the following six items can classify as knee osteoarthritis in patients: age above 50 years, morning stiffness lasting less than 30 minutes ,crepitus on knee motion, bony tenderness ,bony enlargement, no palpable warmth. The severity of osteoarthritis can be assessed using the Kellgren and Lawrence system for classification of osteoarthritis of knee.[11]

Recent literature studying morphological changes in the vastus medialis muscle in patients with osteoarthritis of the knee suggested that all the muscle specimens exhibited atrophy of the type 2 fibers. The lying multifactorial etiology contributes to selective atrophy reflecting on pain related immobilization, along with changes in neurogenic muscular atrophy, muscle fiber regeneration and degeneration might as well add on to the development or progression of Osteoarthritis.

In osteoarthritis, there is selective atrophy of type 2 muscle fibers of vastus medialis muscle.[3] There is reduction in the size and number of myofibers .Changes such as neurogenic muscular atrophy, muscle fiber degeneration, and regeneration might contribute as cofactors in the development or progression of OA.[4] Chronic changes in the muscles such as calcification, fibrosis, and lipomatosis are also observed .

Corresponding author:* **Mamta Shetty
MGM School of Physiotherapy, MGM Institute of Health Sciences,
Navi Mumbai, Maharashtra, India

All of the above mentioned changes alter the motor unit recruitment pattern leading to altered activation of VMO muscle[4] Inability to optimally activate the VMO may be due to two mechanisms, Cortical inhibition and reflex spinal mechanism (AMI).[6] In Cortical inhibition, prolonged peripheral inflammation causes increase in the excitability of ascending nociceptive pathway, which in turn causes dysfunction of descending modular system and decrease in the excitability of inhibitory interneurons. Arthrogenic muscle inhibition (AMI) is a clinical impairment characterized by a reflexive inhibition of the motor neuron pool in uninjured muscles surrounding an injured joint. This reflex inhibition, modulated by both presynaptic and postsynaptic spinal mechanisms, decreases the ability of the muscle to recruit motor neurons during a contraction, thus limiting the potential force a muscle can generate. [6]

Application of Low TENS increases quadriceps motor neuron pool excitability, hence providing an optimal environment for treating reflex modulated inhibition, which may provide a stimulus for regaining normal motor function. [5] Application of TENS immediately increases voluntary quadriceps activation. TENS causes increase in stimuli interpreted as excitatory by interneurons, giving rise to increased motor output of the inhibited musculature. [5] Moreover, there is increase in neural excitability when there is active stimulation along with application of TENS. There are several studies that suggests that peripheral electrical stimulation modulates the motor cortex excitability.[5] Studies suggest that application of TENS can induce transient reciprocal inhibitory and facilitatory changes in corticomotoneuronal excitability. [5]

There is paucity of literature showing the effect of low intensity TENS on the activation of muscle fibers. As there is selective atrophy of type 2 muscle fibers of the vastus medialis obliques muscle, the effect of Low intensity TENS on this specific muscle and its overall effect on pain, function and strength in OA knee patients' needs to be studied.

METHODOLOGY

Thirty eight participants between age age group of 50-70 years were recruited for the study. An informed consent was sought from all the participants. Participants presenting with knee pain along with at least 3 out of 6 ACR (American College of Rheumatology) clinical classification criteria for OA knee or/and Kellgren and Lawrence classification system for OA knee ≥ grade 1 and ≤ grade 3 were included for the study.

The participants were assessed pre intervention (0 weeks), mid intervention (the 6th week) and post intervention (at the end of 12 weeks) by using Numerical Rating Scale, 30 second chair stand test, modified WOMAC (Western Ontario and McMaster Universities Osteoarthritis Index) and Berg Balance Scale as outcome measures. Participants were randomly allocated into two groups as follows: Group A were given low intensity TENS over the bulk of Vastus Medialis Obliques muscle and conventional exercises for osteoarthritis knee. Group B were given only conventional exercises for osteoarthritis knee.

Statistical Analysis

Data was analyzed using SPSS software (Version 24 ; USA, 2019) and Shapiro- Wilk test was used to assess normality. For the inter group analysis, the data which followed normal distribution, independent t-test was applied and for the data which was not normally distributed Mann Whitney U test was done. For the intra group analysis, the data which followed normal distribution, paired t- test was applied and for the data which was not normally distributed Repeated measures ANOVA was applied. A statistical significance level of 0.05 was set for inferential testing.

METHODOLOGY

Participants were explained in detail about the purpose of the study, procedure, clinical evaluation, equipments used and benefits of the study in a language best understood by them. A purposive random sample of thirty-eight participants with chronic osteoarthritis knee in the age group of 50-70 years as per the ACR diagnostic criteria were recruited. Participants fulfilling the inclusion criteria were recruited for the study.

The participants were assessed pre intervention (0 weeks), mid intervention (the 6th week) and post intervention (at the end of 12 weeks) by using Numerical Rating Scale, 30 second chair stand test, modified WOMAC (Western Ontario and McMaster Universities Osteoarthritis Index) and Berg Balance Scale as outcome measures. Participants were randomly allocated into two groups as follows: Group A were given low intensity TENS over the bulk of Vastus Medialis Obliques muscle and conventional exercises for osteoarthritis knee. The frequency of TENS was kept 2-5Hz with a pulse width of 200-300ms. Group B were given only conventional exercises for osteoarthritis knee. A written consent was sought from all participants. A case record form was recorded for each participant of both groups. Pain assessment was assessed using NRS (Numerical Rating Scale) during pre (0weeks), mid (6th week) and post (end of 12 weeks) assessment. Tightness of hamstrings, gastrocnemius-soleus, adductors of hip and tensor fascia lata were assessed manually. Range of motion of hip, knee and ankle joints were assessed using universal goniometer. The strength of hip, knee and ankle joint musculature was assessed manually.

Participants in both groups were given strengthening exercises for their involved lower extremity 3 times per week for 12 weeks. The goal of the 12week exercise program was to increase lower limb strength and function thereby decreasing pain. Strengthening exercises was systematically progressed using a Daily Adjustable Progressive Resistive Exercise (DAPRE) system.[9] All the participants were challenged to increase weight, as directed by the DAPRE system, while maintaining no more than minimal discomfort throughout the exercise session. The DAPRE technique is based on the concept of systematic progression such as periodized strength training regimen where training variables (rest overall training volume, sets per workout, repetitions per set and intensity of training) are manipulated over a period of time in order to optimize adaptations to increase strength ultimately. From a total duration of 30 minutes of application of Low TENS, exercises were performed after a 10 minute period of accustomization by the participants in Group A.[11]

RESULTS

A total of 38 (19 - interventional group and 19 - conventional group) patients were enrolled for the study. The mean age of group A was 55 and group B was 58.7 respectively. The mean BMI of group A is 26.38 and for group B was 25.71. Male to Female Ratio was 1:2.8 in Group A and 1:2.1 in Group B. The demographic details of group A and B are represented in table 1, table 2, and Figure 1.

Table 1 Mean Age and BMI

Demographic Data	Group A (n=19)		Group B (n=19)	
	Mean	SD	Mean	SD
Age (years)	55.00	5.74	58.78	5.95
BMI	26.38	3.76	25.71	2.28

Table 2 Male -Female Ratio of participants

Gender	Group A (n=19)	Group B (n=19)
Male	5	6
Female	14	13

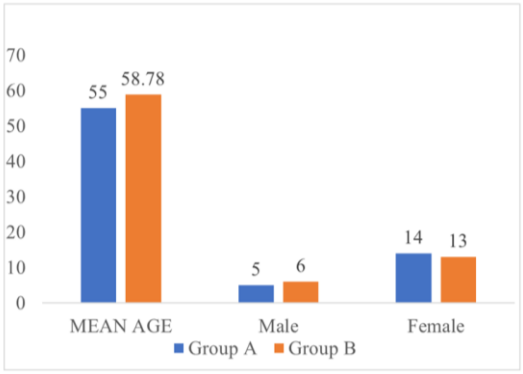
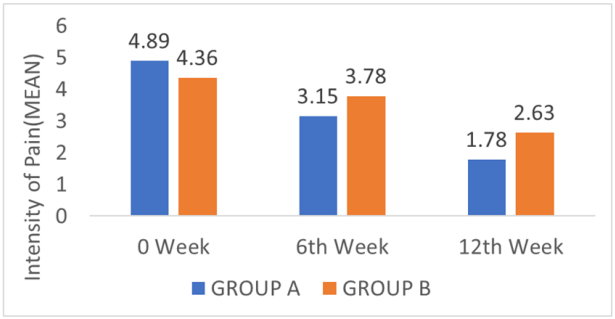


Figure 1 Demographic Characteristic of participants in group A and Group B

The effect of low intensity TENS on vastus medialis obliques activation in chronic osteoarthritis knee for pain, function and strength were studied. The outcome measures used were Numerical Rating Scale, Bergs Balance Scale, Modified WOMAC scale and 30 Second Chair stand Test. The scores of all the above mentioned outcome measures is depicted in table 3. No statistical significant improvement was noted on inter group comparison in pain (p= 0.086), function (p= 0.066) and strength (p=0.190) post 12 weeks of intervention. The pain intensity as measured on the Numerical Rating Scale(NRS) reduced in both the groups, but drastically in Group A as the reduction was almost half of the reduction of Group B during both mid and post assessment (Figure 2).

Figure 2 Numerical Rating Scale (NRS) scores of participants in group A and Group B



Modified WOMAC scores reduced rapidly in Group A compared to Group B indicating an earlier improvement in function in group A (Figure 3). There was an improvement in the mean scores of 30 Second Chair Stand Test in Group A in comparison to Group B (Figure 4).

The findings of this study report improvement in Bergs Balance Scores of both the groups; Group A representing more improvement compared to Group B (Figure 5).

Outcome Measures	0 week (PRE)		6th week (MID)		12th week (POST)		p value
	A (Mean ± SD)	B (Mean ± SD)	A (Mean ± SD)	B (Mean ± SD)	A (Mean ± SD)	B (Mean ± SD)	
Numerical Rating Scale (NRS)	4.89 ±0.80	4.36 ±0.83	3.15 ±1.38	3.78 ±1.03	1.78 ±1.65	2.63 ± 1.30	0.086
30 Chair Stand Test (CST)	9.00 ±3.44	8.31 ±2.42	10.78 ±3.27	9.00 ±2.62	13.84 ±8.65	10.10 ±2.80	0.190
Berg Balance Scale (BBS)	46.78 ±7.64	47.42 ±8.30	49.84 ±6.10	48.94 ±7.34	52.63 ±4.28	50.31 ±6.74	0.678
WOMAC pain	8.57 ±4.50	11.05 ±3.59	5.47 ±4.65	9.52 ±3.73	2.36 ±2.11	7.00 ±3.41	0.034
WOMAC Stiffness	4.26 ±1.69	4.42 ±1.21	2.94 ±1.84	4.42 ±1.21	1.21 ±1.03	3.10 ±2.07	0.012
WOMAC ADL	43.94 ±8.44	40.47 ±11.78	31.36 ±11.08	35.21 ±13.29	19.15 ±9.85	27.10 ±12.93	0.178
WOMAC Total	56.78 ±12.48	55.94 ±14.67	39.63 ±15.10	48.89 ±16.78	22.63 ±11.06	37.36 ±17.30	0.066

Figure 2 Numerical Rating Scale (NRS) scores of participants in group A and Group B

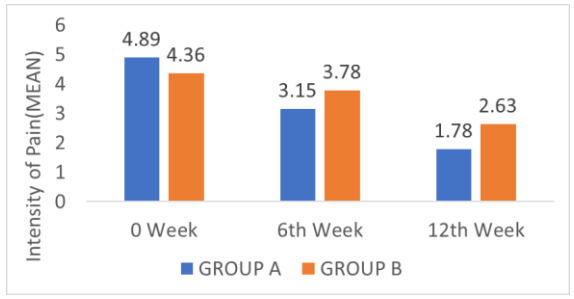


Figure 3 Modified WOMAC Scores of participants in group A and Group B

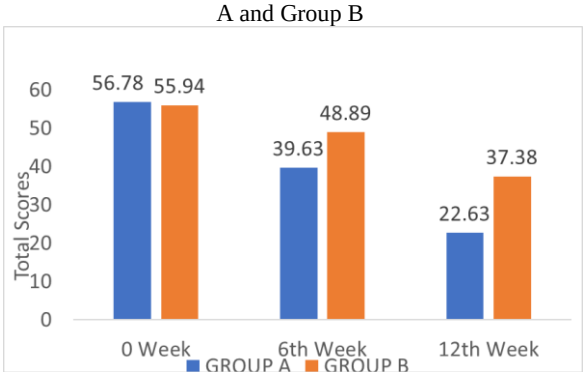


Figure 4 Mean of 30 Second Chair Stand Test Scores of participants in group A and Group B

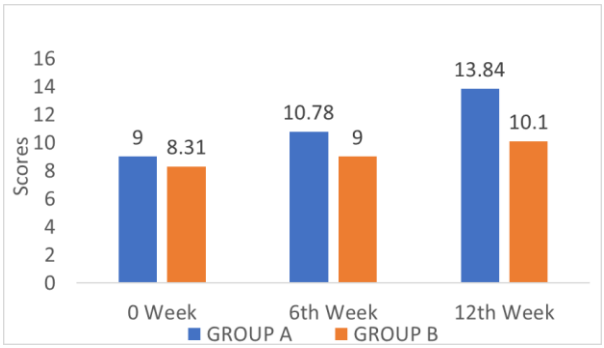
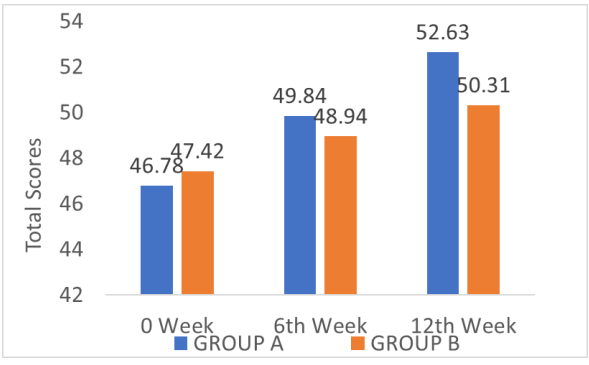


Figure 5 Bergs Balance Scores of participants in group A and Group B



DISCUSSION

Findings from the present study report Low TENS and therapeutic exercise to be effective as compared to conventional exercises for activation of Vastus medialis obliques in patients with chronic osteoarthritis of knee. The authors reported that the total WOMAC scores decreased over a period of 12 weeks in both the groups, but better and faster results were obtained in Group A. Pain, stiffness and function WOMAC subscales followed the same pattern of significant reduction in both groups over a period of 12 weeks while having larger reduction in scores of Group A at both 6^{th} and 12^{th} week.

The reduction in pain could be due to use of TENS which is known to reduce pain associated with osteoarthritis of knee, which potentially leads to better function, improved quality of life.[24,25] TENS increases quadriceps motor neuron pool excitability, hence providing an optimal environment for treating reflex modulated inhibition, which may provide a stimulus for regaining normal motor function. [21] TENS also improves knee stiffness in osteoarthritis patients as there is reduction in pain. [25] For participants in Group B, the decrease in the total scores of WOMAC could have occurred due to exercises leading to an increase in the blood supply causing hypertrophy of muscles and washout of inflammatory mediators. Exercises increase the number of mitochondria and hence the ATP turnover is increased. There is stimulation of collagen and proteoglycan synthesis, therefore increasing the structural strength. Pain reduction causing improvement in function and reduction in disability. [24,25]

In Group A, reduction in pain could be due to segmental mechanism. TENS reduces ongoing nociceptive cell activity and sensitization in the central nervous system when applied to somatic receptive fields. TENS-induced A-δ activity causes long-term depression of central nociceptive cell activity. The intention of Low Intensity TENS is to stimulate small diameter, high threshold peripheral afferents (A-delta) in order to activate extra segmental descending pain inhibitory pathways. Non-painful muscle twitches occur during stimulation causing activity in small diameter muscle afferents. [24,25,28] In Group B, increase in the physical activity leads to 'Primary hyperalgesia' which refers to increased sensitivity of peripheral nociceptors at the site of tissue damage. Research shows that regular exercise promotes cartilage homeostasis and reduce inflammation. [30] Cytokines are an important part of most inflammatory processes in the body. In OA knee increased levels of several cytokines, including interleukin (IL)-6, IL-8, IL-1B, and IL-15, have been observed. IL-1B induces the release of prostaglandins and nitrous oxide, which ultimately results in reduced proteoglycan synthesis and reduced extracellular cartilage matrix. [30] Dynamic compression which is achieved by exercises counteracts the release of prostaglandins and nitrous oxide, thereby inhibiting the inflammatory process. [30]

There was a significant improvement in the balance scores of both the groups. Group A showed better results than Group B. Patients with knee osteoarthritis have a high prevalence of falls, a factor contributing to mobility limitations and difficulties with activities of daily living. Balance is controlled by multiple sensory inputs from visual, vestibular, and proprioceptive pathways, central processing, and neuromuscular responses. [23,27] Deterioration in balance may be accompanied by reduced function in sensory system, declining neuromuscular responses, or problems in central processing. Age-related deterioration in balance can contribute to decreased independence, with increased fear and frequency of falls in elderly. Patients with knee OA typically have impairment of proprioception within the joint or weakness in the quadriceps muscles as compared with those without knee OA. [29]Stiffness and poor mobility in the joints make some people change the way they move. People with OA in their knee or hip tend to compensate for joint damage by shortening their stride or widening their step, practices that impair their balance. As quadriceps weakness is one of the factors related to progression of knee OA, strength training is vital in increasing muscle power, that in turn may affect the balance. Hence, an improvement in the strength and function of the knee joint led to an improvement in the balance of the patients via both exercise and stimulation protocols respectively. [23,27,29]

The study reported that the 30 second chair stand test scores increased over a period of 12 weeks in both the groups. The results support the supposition that application of low TENS increases voluntary quadriceps activation. Low TENS causes increase in stimuli interpreted as excitatory by inter-neurons, giving rise to increased motor output of the inhibited musculature.[26] With exercises the strength of the knee musculature is improved because of the increased synovial fluid secretion, enhanced flexibility and stability (by increasing joint proprioception). Several studies suggest that exercise-based program on lower extremity strengthening improves the strength of the lower extremity muscles resulting in improvement in the 30 second chair stand test value.[23,29] Group A showed significant improvement earlier as compared to Group B in all the outcome measures indicating Low TENS in adjunct to conventional exercises may be useful in treatment of chronic osteoarthritis knee.

CONCLUSION

Findings from present study report application of **Low** Intensity TENS for Vastus Medialis Obliques muscle activation along with exercise versus conventional exercises demonstrated no significant difference on chronic osteoarthritis knee patients for pain, function and strength.

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