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"Comparison of Whole Body Vibration With Squat Training Versus Quadriceps Strengthening Exercises on Pain, Balance and Physical Function in Patients With Osteoarthritis of Knee"

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Abstract:

Background and Purpose: Osteoarthritis of knee is a degenerative disorder associated with advancing age and is characterized by degradation and erosion of articular cartilage, inflammation of synovial membrane, sclerosis of subchondral bone and formation of osteophytes. The aim of this study was to evaluate the effects of whole body vibration with squat training versus quadriceps strengthening exercises on improving pain, balance and physical function in patients with Osteoarthritis of knee.

Design: Comparative study

Methods: 34 subjects with osteoarthritis of knee who fulfilled the inclusion and exclusion criteria were selected for the study and 17 subjects were randomly assigned to each group. Group A received whole body vibration with squat training and Group B received quadriceps strengthening exercises with TENS. Treatment was given for a period of 8 weeks. Pre-test and post-test evaluation was done with NPRS, TUG and KOOS.

Results: NPRS- when comparing between the groups the post test mean of NPRS for Group A showed a decrement from 7.76 to 4.65 and Group B was 8.06 to 5.41 which was statistically significant ($p<0.001$). TUG -when comparing between the groups the post test mean of TUG for Group A showed a decrement from 27.12 to 18.29 and Group B was 26.47 to 20.65 which was statistically significant ($p<0.001$). KOOS- when comparing between the groups the post test mean of KOOS for Group A showed a decrement from 89.76 to 60.94 and Group B was 93.59 to 82.59 which was statistically significant ($p<0.001$).

Conclusion: This study concludes that both whole body vibration with squat training and quadriceps strengthening exercises with TENS is effective in treating the patients of osteoarthritis of knee. However, whole body vibration with squat training showed more improvement in balance and physical function when compared to Quadriceps strengthening exercises in patients with osteoarthritis of knee.

Keywords: Osteoarthritis of knee, whole body vibration with squat training, quadriceps strengthening exercises, TENS.

INTRODUCTION:

Arthritis is derived from the Greek term "disease of joints". It is defined as an acute or chronic joint inflammation that co-exists with pain and structural damage. The most common forms are osteoarthritis and rheumatoid arthritis[1]. Osteoarthritis usually occurs with advancing age and the most commonly affected joints are fingers, knees and hip. Osteoarthritis (OA) is primarily confined to one or more synovial joints and its surrounding soft tissues. Two most predominant pathological features seen in osteoarthritis are progressive destruction of articular cartilage and formation of bone at the margins of joint[2].

Knee osteoarthritis is the most common form of degenerative joint disease affecting both men and women[3,4]. The incidence of knee OA is expected to increase over the next decades. Knee osteoarthritis is directly related to disabilities due to pain, quadriceps dysfunction and impaired proprioception. Moreover, knee OA is responsible for the impaired ability of the quadriceps muscle to control force in patients with knee OA.

Knee OA is associated with advancing age and is characterized by the degradation and erosion of articular cartilage, inflammation of synovial membrane, sclerosis of subchondral bone and formation of osteophytes causing arthritic symptoms such as joint pain, swelling, stiffness, deformation and loss of function in middle aged and elderly people[5]. The medial compartment is affected most frequently (85%), with or without misalignment in the lower limbs[6,7].

Osteoarthritis is the 2nd most common rheumatologic problem and it is the most frequent joint disease with a prevalence of 22% to 39% in India. Osteoarthritis is more common in women than men, but the prevalence increases dramatically with age. Nearly, 45% of women over the age of 65 years have symptoms while radiological evidence is found in 70% of those over 65 years.

Osteoarthritis of knee a major cause of mobility impairment, particularly among females. Osteoarthritis was estimated to be the 10th leading cause of non-fatal burden[8].

Risk factors of Osteoarthritis involves systemic factors and local factors. Systemic factors includes age, gender, race, genetics, metabolic or endocrine, high bone density, nutritional status (eg: Vitamin D deficiency), obesity. Local factors include obesity, major joint trauma (eg: ACL rupture), repetitive stress(occupation), muscle weakness, altered joint biomechanics , joint malalignment and proprioceptive impairments[2].

Etiology of Osteoarthritis of knee- occupational tasks involving heavy lifting and involving kneeling and heavy lifting are related to development of knee osteoarthritis. Malalignment, including varus and valgus deformities and leg length discrepancy are associated with greater prevalence of knee respectively[2].

OA of knee is classified as either primary or secondary, depending on its cause.

Primary knee OA is the result of articular cartilage degradation without any known reason. This is typically thought of as degeneration due to age as well as wear and tear.

Secondary knee OA is the result of articular cartilage degeneration due to known reason. Possible causes of secondary knee osteoarthritis are obesity, joint hypermobility or instability, malpositioning of the joint eg: fracture along articular surface (tibial plateau fracture), congenital defects, immobilization and loss of mobility, family history and metabolic causes like rickets.

Joint pathology involves the first osteoarthritic change in articular cartilage, confirmed in humans, is an increase in water content. This increase suggests that proteoglycans have become swollen with water far beyond normal. This process, together with disruption of other components of the extracellular matrix, decreases the stiffness of matrix and leads to further mechanical damage. As the articular cartilage is destroyed, the joint space narrows and as the cartilage degenerates there are accompanying changes in the subchondral bone including increased bone density or subchondral sclerosis, creation of cyst-like bone cavities and formation of marginal osteophytes. Osteophytes may be fibrous, cartilaginous or bony in composition and marginal prominences are palpable and often tender in more superficial joints[2].

Whole body vibration(WBV) exercise is a feasible and curative strength exercise technique that has received considerable attention in recent years[9]. WBV is the exercise program performed with the body on a platform that generates vibrations. These vibrations are transmitted to the body which stimulates the primary endings of the muscle spindles, thereby activating alpha-motor neurons, which cause the muscle contractions similar to the tonic vibration reflex[10].

Recently, WBV training has been explored for the therapeutic treatment of knee osteoarthritis, particularly in the aspects of pain relief and improvement in physical function[11].

The quadriceps are the largest group of muscles crossing the knee joint and have the greatest potential to generate and absorb forces at the knee. Many clinical studies have shown consistent improvements in knee after strength training, as well as reduction in pain and physical disability of people with knee OA[12,13].

Outcome measures:

NPRS: the 11-point numerical pain rating scale is a measure of pain, where 0= no pain and 10= worst imaginable pain[14,15,16,17] and it has been shown to have concurrent and predictive validity as a measure of pain intensity[15,18].

The Timed Up and Go(TUG) test is a reliable, cost-effective, safe and time-efficient way to evaluate overall functional mobility. The TUG has a high correlation with other proven tests that measures pure gait speed for longer lengths such as 10-m walk[19].

The knee injury and osteoarthritis outcome score(KOOS) scale is a knee-specific instrument, developed to assess the patients opinion about traumatic knee injuries and osteoarthritis. The KOOS is a 42-item self-report questionnaire that has 5 reported dimensions: pain (9 items), other symptoms (7 items), function in daily living (17 items), function in sport and recreation (5 items). The scoring system of the KOOS utilizes a 5 point Likert scale, with anchors of zero(no problems) to 4 (extreme problems)[20].

PURPOSE OF THE STUDY:

Osteoarthritis knee is a degenerative joint disease commonly affecting the elder people leading to pain, loss of muscle strength, balance and function.

Whole body vibration (WBV) training has recently gained popularity in the field of Physiotherapy for treating musculoskeletal conditions such as osteoarthritis of knee, low back pain, osteoporosis, chronic Achilles tendonitis, etc. whole body vibration has an effect on improvement of muscle strength, power, joint proprioception, balance and flexibility. The vibrations are generated by a vibrating plate and are transmitted from surfaces in contact with the human body to stimulate muscles and tendons. Few studies have shown that whole body vibration with squat training shows better effect on pain relief in osteoarthritis of knee.

Quadriceps strength training will increase quadriceps force and negative work and thereby unload the tibiofemoral joint while walking. Strength and function od quadriceps decline with age and studies have shown positive outcomes of quadriceps strengthening on pain relief and improving joint function.

As there is less literature on the effect of whole body vibration with squat training on Osteoarthritis of knee, this study was done to find out the positive effects of whole body vibration with squat training on patients with osteoarthritis of knee and also to compare it with quadriceps strengthening on improving pain, balance and function.

OBJECTIVES OF THE STUDY

1. To find out the effect of whole body vibration (WBV) with squat training (ST) in patients with Osteoarthritis of knee.
2. To find out the effect of Quadriceps strengthening exercises (QSE) and Transcutaneous electrical nerve stimulation (TENS) in patients with Osteoarthritis of knee.
3. To compare the effect of whole body vibration (WBV) with squat training (ST) versus the effect of Quadriceps strengthening exercises (QSE) and TENS on pain, balance and physical function in patients with Osteoarthritis of knee.

HYPOTHESIS OF THE STUDY

NULL HYPOTHESIS (H_0): There will be no significant difference of whole body vibration with squat training and quadriceps strengthening exercises in patients with Osteoarthritis of knee.

ALTERNATE HYPOTHESIS (H_1): There will be significant difference of whole body vibration with squat training and Quadriceps strengthening exercises in patients with Osteoarthritis of Knee.

MATERIAL:

- Whole body vibration machine
- Goniometer

- Stopwatch
- One chair with armrest
- Tape(to mark 3 meters)
- Resistance bands
- Transcutaneous electrical nerve stimulation(TENS) modality

SOURCES OF DATA:

For the purpose of data collection 34 subjects within the age group of 50-65 years diagnosed with grade 3 or less of Kellgren-Lawrence grades Osteoarthritis of knee in the Department of Physiotherapy or referred to the Department of Physiotherapy in Grace College of Physiotherapy, & Grace Multispecialty Hospital, Khammam.

SAMPLE AND SAMPLING TECHNIQUES:

34 patients within the age group of 50-65 years with clinical diagnosis of osteoarthritis of knee (grade 3 or less of Kellgren-Lawrence classification) were selected on full filling the inclusion and exclusion criteria from the Department of Physiotherapy in NMCH. They were divided into two groups by Simple Random Sampling Technique.

$Z_{\alpha/2}$ = 1.96 standard normal variate at 95% confidence level Z_{β} =0.84 at 80% power

d = mean difference= 47.8 σ = pooled SD= 49.82

Sample size formula:

$$n = \frac{2[Z_{\alpha/2} + Z_{\beta}]^2 [\sigma]^2}{d^2}$$

$$n = \frac{2[1.96+0.84]^2[49.82]^2}{(47.8)^2}$$

$$= 17.03 \cong 17$$

17 is the sample size for each group.

Therefore, total sample size consists of 34 subjects- 17 subjects in each group

INCLUSION CRITERIA:

- Subjects of age group between 50-65 years.
- Subjects diagnosed with Osteoarthritis of Knee of grade 3 or less of Kellgren and Lawrence classification.
- Both genders.
- Subjects who has not suffered any recent injury.
- Subjects who has not been used glucocorticoids for at least 2 months prior the study.
- Subjects willing to participate in the study.

EXCLUSION CRITERIA:

- Subjects with Orthopaedic, neurological, respiratory or acute cardiac diseases.
- Subjects with cognitive deficits determined by mini mental status examination.
- Subjects with Recent knee surgeries.
- Subjects with history of knee damage in recent 6 months.
- Subjects with Lower extremity deformities.
- Subjects with history of trauma in previous weeks, any muscular, neurologic conditions.
- Subjects with Rheumatoid arthritis, upper limb or lower limb fractures in last 6 months which affect squat training or any lower limb prostheses.
- Subjects not willing to participate in the study.

METHODS OF DATA COLLECTION:

- Numerical pain rating scale(NPRS)
- Knee injury and Osteoarthritis Outcome score (KOOS)
- Timed up and go test(TUG test)

METHODOLOGY:

- 34 participants fulfilling inclusion and exclusion criteria regardless of their gender will be selected for the study.
- The formal informed consent shall be obtained and signed by the subjects themselves or their guardian.
- Using simple random sampling technique, 34 subjects will be assigned into two groups.
- Group A: 17 subjects will receive Whole body vibration with squat training.
- Group B: 17 subjects will receive quadriceps strengthening exercises and TENS.
- Subjects will be assessed using outcome measures before and after the program schedule of 8 weeks.
- The entire regime will be explained to the participants prior to the onset of their treatment program.
- Duration of the program: 8 weeks.

PROCEDURE:

1) GROUP A: WHOLE BODY VIBRATION (WBV) WITH SQUAT TRAINING (ST):

- Participants in the WBV + ST group shall attend the training program 3 days per week with at least 1 day between each session for 8 weeks. Training will be conducted using a vibration device.
- All sessions will be supervised by the therapist. Resistance bands shall be used to prevent participants from falling backwards during training.
- Without being stretched, one side of the band will be tied to the handle of the platform and the other side will be held by the participant. The participants will perform static Squat training on the vibration platform without shoes.
- The participants will be instructed to flex their knee at 30° and 60° without knee varus. Before each training session, the therapist will adjust the angle of knee flexion with a goniometer.
- The distance between the feet will be consistent with the shoulders. The training volume per session will be increased progressively over the 8-week intervention period by increasing the hold time, number of sets, and total time (Table 1). The vibration parameters will be as follows: frequency of 20 Hz, amplitude of 2 mm, and vertical vibration.

Table 1: The protocol of WBV+ST intervention

Week of intervention	Knee flexion angle	Hold time	Rest time	Number of set	Total time
1	30°	30s	30s	6	12 min
	60°	30s	30s	6	
2	30°	40s	40s	6	14 min
	60°	30s	30s	6	
3	30°	40s	40s	7	17 min
	60°	40s	40s	6	
4	30°	50s	50s	7	21 min
	60°	40s	40s	7	
5	30°	50s	50s	8	25 min
	60°	50s	50s	7	
6	30°	60s	60s	8	29 min
	60°	50s	50s	8	
7	30°	60s	60s	9	34 min
	60°	60s	60s	8	

8	30°	70s	70s	9	39 min
	60°	60s	60s	9	

WBV+ST, whole body vibration + squat training.

2) GROUP B: QUADRICEPS STRENGTHENING EXERCISES AND TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION

GROUP B: QUADRICEPS STRENGTHENING EXERCISES

The subjects in group B will perform the following sets of exercises for 8 weeks.

- Isometric quadriceps exercise: patients will lie in a supine position and a rolled up towel shall be placed beneath the knee. Patient will be instructed to maximally contract their thigh muscles in order to straighten their knee and hold the contraction for 5 seconds.
- Straight leg raising (SLR) exercise: Patients will lie in a supine position. They will be instructed to perform a maximum isometric quadriceps contraction prior to the lifting phase of the exercise. Then they will be instructed to lift the leg up to 10cm above the plinth and hold the contraction during the lifting phase for 5 seconds.
- Isometric hip adduction exercise: Patients will lie in a supine position with both the knees bent. A small pillow will be placed between the knees. They will be instructed to perform isometric hip adduction exercise by pressing the pillow between the knees and to maintain the contraction for 5 seconds.

Frequency and volume of exercise

- Each of these exercises will be performed in 3 sets of 10 repetitions 5 days/week for 8 weeks.
- Adequate rest periods will be incorporated in between the sets.

TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION (TENS)

- High TENS (100 Hz) – 20 minutes/ day given for 5 days per week for 4 weeks.

RESULTS:

Study Design**:** A Comparative study was done consisting of 34 subjects randomized into 2 groups with 17 subjects in group A (whole body vibration with squat training), 17 subjects in group B (quadriceps strengthening exercises), to study the significant differences between 2 groups receiving treatment.

Table 1: Demographic data:

variables	Group A	Group B	P Value
Gender(male/female)	10/7	10/7	1.000
age	54.71±3.653	55.59±4.514	0.535

Table 2: within group comparison of outcome measures

Outcome measure	Group A			Group B		
	pre	post	P value	pre	post	P value
NPRS	7.76±0.562	4.65±0.492	<0.001	8.06±0.747	5.41±0.618	<0.001
TUG	27.12±1.111	18.29±1.046	<0.001	26.47±1.067	20.65±0.931	<0.001
KOOS	89.76±6.543	60.94±4.827	<0.001	93.59±6.577	82.59±6.413	<0.001

P<0.001 values are expressed as mean and standard deviation, NPRS: Numerical pain rating scale. TUG- Timed up and go test. KOOS: The knee injury and osteoarthritis outcome score (KOOS) scale.

Table 3: Between group comparison of outcome measures

Outcome measure	Group A		Group B	
	Pre	post	pre	post
NPRS	7.76±0.562	4.65±0.492	8.06±0.747	5.41±0.618
TUG	27.12±1.111	18.29±1.046	26.47±1.067	20.65±0.931

KOOS	89.76±6.543	60.94±4.827	93.59±6.577	82.59±6.413

P<0.001 values are expressed as mean and standard deviation, NPRS: Numerical pain rating scale. TUG- Timed up and go test. KOOS: The knee injury and osteoarthritis outcome score (KOOS) scale.

DISCUSSION:

Knee osteoarthritis (KOA) may be a cause of chronic pain with progressive disability, causing a significant impact on the quality of life of individuals, mainly in the elderly.

The principle aim of this research study was to compare the effect of whole body vibration with squat training and quadriceps strengthening exercises in patients with osteoarthritis of knee. This study was conducted on 34 subjects having osteoarthritis knee which were divided into 2 groups with 17 subjects in each group. Group A received whole body vibration with squat training and Group B received Quadriceps strengthening exercises with TENS. NPRS was used to assess pain, Tug test was used to assess balance and KOOS was used to assess physical function.

Treatment was given for 8 weeks.

Subjects in group A who received whole body vibration with squat training showed a decrement in NPRS to a mean of 4.65 post treatment which was 7.76 before treatment. The TUG test showed a decrement to a mean of 18.29 post treatment which was 27.12 before treatment. The KOOS also showed a decrement to a mean of 60.94 post treatment which was 89.76 before treatment. The results showed a highly significant difference in all the 3 scales.

The results of this study correlates with the study done by Young Geun Park et al[21] to evaluate the effect on pain reduction and strengthening of the whole body vibration in Chronic Osteoarthritis of knee. Group A received Whole body vibration with home based exercises.

Group B received only home based exercise. Treatment was given for 3 times a week for a period of 8 weeks. The outcome measures used were numerical rating scale(NRS), Korean western Ontario McMaster score(KWOMAC), Lysholm Scoring scale(LSS), isokinetic torque, isometric torque and Biodex Stability system. Study concluded that Whole body vibration showed better results in reducing pain, strengthening of the quadriceps muscle and dynamic balance.

Subjects in group B who received quadriceps strengthening exercises for knee pain, balance and physical function also showed an improvement in NPRS scores from pre test mean of 8.06 to 5.41. The TUG showed an improvement from pre-test mean of 26.47 to 20.65. The KOOS also showed an improvement from pre-test mean of 93.59 to 82.59. The quadriceps strengthening exercises group also showed a significant difference in the mean results.

These results are in agreement with the study done by Aline Mizusaki Imoto et al[22] to see the effectiveness of Quadriceps strengthening exercises through pain, function and quality of life in patients with knee osteoarthritis. 100 patients were randomly assigned into 2 groups i.e Exercise group and Orientation group. The outcome measures were NRS, TUG and SF-36. Study concluded that Quadriceps strengthening exercises are effective in the improvement of pain, function and quality of life in patients with knee Osteoarthritis.

TENS was also part of the treatment program in Group B. TENS is based on the Gate-Control theory of pain perception as described by Melzack and Wall. This theory suggests that afferent stimulation, such as electrical stimulation competes with painful stimulation in the spinal cord level, which attenuates the perception of pain at the central nervous system.

Cemile Sevgi Polat et al[23] conducted a study to evaluate the efficacy of transcutaneous electrical nerve stimulation (TENS) in knee osteoarthritis with neuropathic pain component. The outcome measures used were visual analogue scale (VAS), Western Ontario and McMaster osteoarthritis index (WOMAC), painDETECT questionnaire for presence of neuropathic pain. All patients received hot pack, TENS (20 min/day) and was applied at a frequency of 80 hertz with 10 to 30mA intensity and home exercise program. Intervention was given for 5 days a week for a period of 3 weeks. Study concluded that the TENS is effective in reducing pain and improving physical function with and without neuropathic pain in osteoarthritis of knee patients.

In this Study, the inter group comparison between the Group A(whole body vibration with squat training) and group B(Quadriceps strengthening exercises with TENS) showed a significant difference in all 3 scales, however when the mean of both the groups were compared, Group A was found to be more effective in improving balance and physical function in osteoarthritis knee patients. This result indicates significance differences for group A and group B favouring group A over group B.

Hence, the result of this study showed that interventions given to both the groups showed improvement in NPRS, TUG and KOOS. But, based on the post test comparison between the two groups it can be said that Whole body vibration with Squat training showed better improvement in balance and physical function in patients with osteoarthritis of knee.

CONCLUSION:

This study concluded that both whole body vibration with squat training and quadriceps strengthening exercises were effective in the management of patients with osteoarthritis of knee. However, when the post test values were compared, whole body vibration with squat training showed better improvement in balance and physical function over the quadriceps strengthening exercises in patients with osteoarthritis of knee.

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