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EFFECT OF WHOLE BODY VIBRATION ON LOWER BODY STRENGTH AND BALANCE IN OSTEOARTHRITIS KNEE

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ABSTRACT

Background: Knee osteoarthritis causes pain, functional limitation, and disability in the elderly. Whole-body vibration has gained a lot of attention in recent years. It is currently used in alleviating pain and improve physical function along with strength and balance.

Methods: 34 individuals aged between 50-70 years fulfilling the inclusion criteria were selected and randomized into two groups. Baseline assessment was done using the VAS scale, WOMAC scale, Berg Balance Scale, and 30seconds chair stand test. Group A received whole-body vibration, and knee strengthening exercises, and group B received only strengthening exercises. The treatment was given thrice in a week for four weeks. The assessment was done by the end of the 2nd and 4th weeks.

Results: Whole body vibration had shown greater improvement of VAS on rest ($p<0.05$) compared to VAS on activity. Also, the WOMAC score was statistically improved between and within the group with $p<0.05$.

Conclusion: Whole body vibration, along with strengthening exercises, showed superior effects in reducing pain, stiffness, physical function, balance, and lower limb strength in osteoarthritis knee patients.

Keywords: Pain, Mobility, Quadriceps Femoris, 30-second Chair Stand Test, WOMAC, Berg Balance Scale.

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INTRODUCTION

Osteoarthritis presents with stiffness and limitation in the articular functions of the knee [1]. Knee osteoarthritis is a chronic degenerative disease that has multi-factorial etiology. It is categorized under non-inflammatory degenerative disease and more commonly found in elderly people. The incidence rate in the elderly was found to be 60-90% [2]. Knee osteoarthritis progresses with the advancing age of the elderly population, which is characterized by attrition of articular cartilage, inflamed synovial membrane, sclerosis of subchondral bones [2].

In Osteoarthritis loss of a normal joint relationship, crepitus sound with movement, bony deformities, excess synovial fluid, and most significant weakness of the quadriceps muscle and sensorimotor loss will be seen [3]. Few arthritic changes in the elderly such as stiffness, pain, swelling, and compromise of function, are experienced by the middle-aged population, too [4].

Women are affected more than men and are at higher risk of developing osteoarthritis. As several hormonal changes take place due to menopausal effects after the age of 50 years, the females undergo various musculoskeletal changes such as osteoporosis, muscle weakness along with the poor alignment of lower extremities; this is majorly because of decreased levels of estrogen. Chondral protection is provided by this hormone [3].

Weight-bearing and related difficulty in the movement has been reported as the most important barrier because of pain experienced knee. Formation of osteophytes, deformities like varus and valgus, instability of the joint and calcification are visible on radiological findings [2]

Osteoarthritis causes functional disability that compromises well being in patients who are elderly with an increased risk of systemic diseases. These patients experience weakness of quadriceps and proprioceptive deficits, which alters the balance and posture control. Also, the swollen joint, which is present in these patients, contributes to pain, which affects afferent information related to movement and joint position sense. These results in proprioception deficits along with muscular instability around the knee joint. So the functional instability and limitation of activities of daily living prevail [3].

Maintaining mobility and reducing pain should be focused as the main goal for the functioning of patients [5]. The neuromuscular function is coordinated by afferent and efferent nerve fibers activity, and so the muscular function will occur [6].

The task of lower extremity strength is crucial for knee joint function. The strength deficit will lower down the shock absorption accompanied in weight-bearing functional activities. The significance behind maintaining lower body strength during advancing age should be considered to note the risk of mobility and balance issues [7]. Having the strength of the lower limb is equally important to prevent disability.

The quadriceps femoris is notably affected in patients with knee arthritis along with the components of both recruitment deficit and atrophy, which contributes to the weakness of quadriceps muscles along with uncontrolled knee joint loading [6]. Also, the age-related advancing changes may deteriorate the performance of the elderly in gait as in rising from a chair or stair climbing or maintaining balance. Balance control is indispensable for a person to have mobility and work independently without assistance from others, though it deteriorates with the advancing age [6].

To measure these variables, several scales and special tests can be used. 30seconds chair stand test is a reliable test. It is important in detecting the lower limb strength for degenerative conditions as well as assessing muscle weakness in the elderly population [7]. The visual analogue scale is used to assess the pain components of the individuals according to the intensities of their pain tolerance. One of the scales that has been suggested for balance is the Berg Balance scale as a clinical test that is used in the elderly population who faces a problem of balance and risk of falls [3].

Whole-body vibration equipment is now a day's got its wider importance, especially in clinical cases. It has a role in maintaining balance, proprioception, blood circulation, and hormone level that enhances the effect on the neuromuscular system. The vibrating plate generates vibrations that are transmitted from the surface to the human body that further stimulate muscles and tendons. This is used as a multi-joint strength performance exercise used for the lower limb, which acts as a counter-jump movement. It also increases the oscillations of the chondrocytes, which augments the thickness of its layer [2].

METHODOLOGY

This experimental study was approved by the ethical committee of Dr. D. Y. Patil College of Physiotherapy, Pimpri, Pune. A total of 45 Patients with knee OA were screened from a Physiotherapy outpatient department of Dr. D.Y. Patil Hospital. All subjects who fulfill inclusion criteria had given written consent. They were conveniently divided into an experimental or control group. Out of 45 screened individuals, 34 (10 males and 24 females)were included based on Inclusion criteria, which were knee OA(Bilateral or unilateral), age 50-70 years, and diagnosed with Grades 1,2, or 3 by Lequense scale. Patients were excluded if they were not co-operative patients, Knee surgery, History of knee damage in recent six months, Lower extremity deformities, History of trauma during the previous week, Any muscular, neurological conditions affecting lower limb functions. After the baseline assessments, patients were assessed for knee ranges, VAS score, 30-second Chair Stand test, Berg Balance Scale, and WOMAC. Four subjects, two from each group, had dropped out of the study as follow up was not consistent.

The overall flow of participant's enrolment in intervention trail shown in fig 1

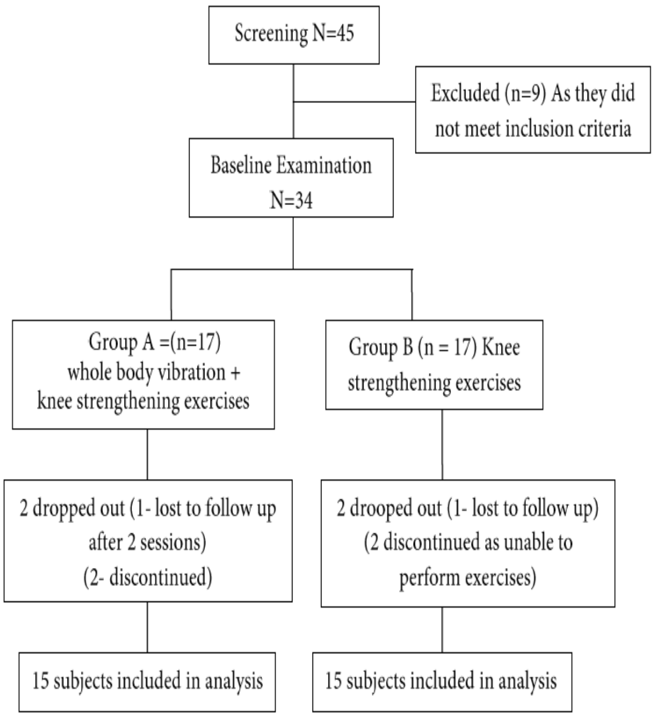

Figure 1: Consort diagramIntervention:

Group A: The experimental group was treated on a whole body vibration machine with the patient's bare feet. Gradually he was asked to perform squats with given hold and rest timings at 25 Hertz frequency. Hold and rest timings had increased from 30 to 60 seconds. In the 4th week number of repetitions has risen from 6 to 7 [8]. Then, the patient performed strengthening exercises the same as a control group [2].

Group B: The control group was given strengthening exercises including isometric quadriceps, Hip Adduction, and Straight leg raise for four weeks, three sessions in a week [9].

Both the groups were assessed for outcomes pre and post at 0 weeks, 2ndand 4th week. The data was analyzed from the participants using Win Pepi software for values obtained before, during, and after the treatment.

RESULTS

Table 1 Showed demographic distribution of gender and mean age in groups A and B, respectively. Mean age (in years) for group A for males and females was 59 ±5.68 and 57.5±7.05 and for group B was 62 ±5.88 and 61±0 in both the groups. Gender distribution for males and females in group A was 46.66% and 53.33% and 13.33% and 86.66%, respectively.

Table1: Demographic data

Variable	Gender	Group A	Group B
Age (in years) (Mean ± SD)	Male	59 ± 5.68	62 ± 5.88
	Female	57.5 ± 7.05	61 ± 0
Gender in %	Male	46.66%	13.33%
	Female	53.33%	86.66%

Table 2 Showed mean score of range of motion for knee flexion and extension in group A are for pre 74.33 and 74.33, mid 80.87 and 79.67 and post 89.67 and 89.67 and similarly for group B for pre 73.67 and 73.67, mid 76.33 and 76.07 and post 81.67 and 81.67 respectively.

Table 2: Mean range of motion for knee flexion and extension for the experimental and control group.

Variable	Group	Pre	Mid	Post
Knee flexion range (n=15)	Experi-mental	74.33 ± 15.91	80.87±15.56	89.67±17.16
	Control	73.67 ± 20.66	76.33±21.73	81.67±20.76
Knee exten-sion range (n=15)	Experi-mental	74.33 ± 15.91	79.67±16.09	89.67±17.16
	Control	73.67 ± 20.66	76.07± 20.74	81.67± 20.76

Table 3 Showed that Mean values for VAS on activity and rest in group A, for an activity for pre was 5.66 ± 1.29, mid 5.2 ± 1.61 and post 4.4 ± 1.54 and for rest pre was 2.8 ± 1.47, mid 2.73 ± 1.48 and post 2.4 ± 1.50. For group, B mean values for activity were 5.93 ± 1.22, mid 5.6 ± 1.35 and post 5.2 ± 1.52 and for rest pre was 3.2 ± 1.69, mid 3.13 ± 1.59 and post 3 ± 1.55. Both the treatments showed equal effect with a statistical significance of p<0.05.

Table 3: VAS on activity and rest within the group on activity and rest in pre, mid and post weeks

Variable	VAS of Experimental group (Mean±SD)		VAS of Control group (Mean±SD)	
	On activity	On rest	On activity	On rest
Pre (0 week)	5.66± 1.291	2.8 ± 1.474	5.933± 1.223	3.2 ± 1.699
Mid(2nd week)	5.2± 1.612	2.73 ± 1.486	5.6 ± 1.352	3.133 ± 1.598
Post(4th week)	4.4 ± 1.549	2.4 ± 1.502	5.2 ± 1.521	3 ± 1.558
p-value	<0.05	<0.05	<0.05	<0.05
r-value	24.174	15.200	9.500	4.667

Table 4 shows that the Mean difference between groups A and B from pre to mid-week and pre to post week was seen. VAS on activity in group A and B in pre to mid-week was 0.466 and 0.33 and from pre to post week was 1.267 and 0.733. Also, VAS on rest in group A and B pre to mid was 0.066 and 0.066 and for pre to post weeks 0.4 and 0.2, respectively. The difference between both the group's p values for VAS on activity in group A and B was 0.574 and 0.048. Also, p values for VAS on rest in group A and B were 0.021 and 0.504

Table 4: Mean difference between VAS on activity and rest in Experimental and Control group from pre to mid and pre to post week in both the groups:

Variable	Group	Pre to mid (Mean±SD)	Pre to post (Mean±SD)	p-val-ue	t-val-ue
VAS on activity (n-15)	Experi-mental	0.466 ± 0.639	1.26 ± 0.593	0.574	0.563
	Control	0.33 ± 0.617	0.73 ±0.593	0.048*	1.978
VAS on rest (n-15)	Experi-mental	0.66 ± 0.258	0.4 ±0.632	0.021*	0.983
	Control	0.66 ± 0.258	0.2 ±0.414	0.504	0.668

*statistically significant

Table 5 Shows Mean WOMAC for group A pre 21.26, mid

19, and post 18 and for group B pre 22.33, mid 19.13, and post 17.2. Group A showed better improvement when compared to group B.

Table 5: Mean WOMAC score for group A and B for pre, mid, and post weeks.

WOMAC SCORE	Experimental (n=15) (Mean±SD)	Control (n=15) (Mean±SD)
Pre (0 week)	21.26 ± 6.029	22.33 ± 6.25
Mid (2nd week)	19 ± 7.38	19.13 ± 5.09
Post (4th week)	18 ± 7.32	17.2 ± 6.68
Df (within-group)	1	1
F value	34.56	1.822
p-value	<0.05	>0.05
Df (between-group)	1	1
F value	296.81	0.03
p- value	<0.05	>0.05

Table 6 Showed mean of Berg Balance Scale from pre to post weeks. For group, A pre 50.33, mid 50.4 and post 51.13 values were seen, and for group B pre 49.33, mid 49.8 and post 50.87 values were seen. Both the groups showed statistically significant improvement p<0.05 to improve balance.

Berg balance score	Experimental group (n=15) (Mean±SD)	Control group (n=15) (Mean±SD)
Pre (0 week)	50.33 ± 6.662	49.33 ± 7.128
Mid (2nd week)	50.4 ± 6.522	49.8 ±6.753
Post (4th week)	51.13 ± 5.153	50.87 ± 6.151
p- value	<0.05	<0.05
r- value	7.538	14.857

Table 6: Mean of berg balance scale in group A and B for pre, mid, and post weeks:

Table 7 shows the mean difference of the berg balance scale between groups A and B from pre to mid and pre to post week. For group A and B pre to mid-week mean difference was 0.066 and 046 and from pre to post week was 0.8 and 1.533. In comparison, the result was not statistically significant.

Table 7: Mean difference of berg balance scale for group a and b from pre to mid and pre to post weeks

Variable	Pre to mid (Mean±SD)	Pre to post (Mean±SD)	p-value	t-value
Berg balance scale in experimental group(n=15)	0.06 ± 0.258	0.8 ± 1.781	0.336	0.963
Berg Balance scale in control (n=15)	0.46 ± 0.915	1.53 ± 1.807	0.219	0.219

Table 8 Showed the mean of 30-second chair stand test pre to post weeks in group A and B. For group A mean for pre, mid and post was 9.4, 9.86 and 10 and in group B 9.733, 9.933 and 10.73. Both the groups were statistically significant in improving the lower limb strength in elderly with p<0.05.

Table 8: 30 seconds Chair Stand test mean for group a and b for pre, mid, and post weeks.

Variable	Experimental (n=15) (Mean±SD)	Control (n=15) (Mean±SD)
Pre (0 week)	9.4 ± 2.197	9.733 ± 3.36
Mid (2nd week)	9.867 ± 2.29	9.933 ± 3.59
Post (4th week)	10 ± 2.591	10.73 ± 3.47
p -value	<0.05	<0.05
r- value	9.220	14.829

Table 9 shows On comparing both the group's mean difference in 30-second chair stand test for group A and B from pre to mid-week was 0.466 and 0.2 and from pre to post week was 0.736 and 0.925. p values from pre to mid and pre to post week were p= 0.480 and 0.429, i.e., statistically insignificant.

Table 9: Mean difference of 30 seconds chair stand test between group A and B from pre to mid and pre to post weeks.

Variable	Pre to mid (Mean±SD)	Pre to post (Mean±SD)	p-value	t-value
30seconds Chair Stand in experimental (n=15)	0.466 ± 0.639	0.6 ± 0.736	0.480	0.707
30seconds Chair Stand in control (n=15)	0.2 ± 1.082	1 ± 0.925	0.429	0.791

DISCUSSION

The present study compared the effects of whole-body vibration along with knee strengthening versus only exercises in knee osteoarthritis patients. The study showed statistically significant results individually, but on the comparison, no significant difference was found for the Berg Balance Scale and 30seconds Chair Stand test. But VAS on rest, along with WOMAC components, had shown statistically more significant results in the group with conventional rehabilitation added to whole-body vibration.

Osteoarthritis is a common musculoskeletal disorder accompanied by degeneration and age-related cartilaginous changes in synovial joints affecting the quality of life.

Along with aging, other modifiable and non-modifiable factors play an essential role in the disease progression. Genetic influence, female gender increases the risk of susceptibility to osteoarthritis. Mal-alignment, weakness of muscles, previous trauma causing knee instability, obesity adds on as risk factors towards osteoarthritis. Also, when instability is accompanied along with mal-alignment of the knee, walking in comparison to standing gets hampered greater. This compromises functional activities due to loss of muscular strength and power much greater with lower extremity than upper extremity [10].

In our study, knee osteoarthritis was more prevalent among the female population with a mean age of 57 and 61 years compared to males of age 59 and 62 years in group A and B.

Studies have shown the importance of mechanical stimulation in the form of joint loading to prevent cartilage atrophy [11]. This highlights the importance of exercise in conservative management of osteoarthritis knee. Isometrics is first, to begin with, followed by advancement to isotonic and then resisted isotonic exercises. Along with traditional protocol, several other physiotherapy interventions such as manual therapy, taping, soft tissue mobilizations, and vibration training have come into use.

Symptoms of knee osteoarthrItis are associated with functional disability and pain, which results in loss of functional capacity, and the activity levels of patients get compromised. Exercises are considered important for arthritic patients as it provides functional exercises which improves muscular activities around the affected joints. It also helps in maintaining range of motion and controls possible further damage. A study by Priyasingh et al. (2016) found out that walking activities are found to reduce pain and functional disability with better results achieved in VAS on rest scores [12].

Vibration treatment can be given locally using vibrator apparatus or globally using a vibrating platform with or without exercises [4].

Studies have shown that whole-body vibration work against decreased cartilage thickness and so will show beneficial effects with osteoarthritis knee.

Pamon (2018) et al. said that quadriceps weakness is a significant risk factor in osteoarthritis knee, decreases the stability of the knee complex, causes mal-alignment issues along with reducing shock attenuating capacity of muscles [13]. Isometric exercises, when trained for quadriceps, causes the least intraarticular inflammation, bone destruction, and pressure over the joint. Also, straight leg raising is an open-chain kinematic exercise involving knee co-contraction maintenance eccentrically against gravity. This helps in improving knee musculature strength and preventing disability. Decrease of disability along with an increase in knee ranges, as seen in the study, shows the reduction of pain with conventional exercise protocol. This helps to restore an optimal function in the joint [14].

A study by Slemenda(1997) suggests that quadriceps weakness results in secondary knee pain along with atrophy, muscle inhibition from joint pain dysfunction, which results in weakness functionally from disuse atrophy [15]. In swollen and painful joints, isometric contraction produces lower articular pressure as tolerated by the patient.

Whole-body vibration at low-frequency vibration desensitizes Meissner corpuscles and Merkel cells. Also, repeated whole-body vibration stimulation increases the influence of afferent threshold sensitivity. This desensitization results from long time exposure to a supra-threshold vibration stimulus applied to the skin. It gets influenced by the intensity and frequency of the stimulus, too [16].

This adaptation induced may be the possible mechanism for the reduction of pain experienced with whole-body vibration. In our study, also frequency set of 25Hz has shown more remarkable improvement compared to conventional protocols for pain at rest [10].

Pain on activity has shown no better results with a vibrator. The reason may be a static position on a vibration platform that doesn't simulate walking like activities.

Many studies have reported that stronger the quadriceps in the elderly, less knee pain and better physical functions are obtained. Muscles should be strong for stabilizing joints, to maintain proper alignment, increase shock absorption, which otherwise will spread to the joint. Weakness in muscles will, therefore, be responsible for disability and pain. In the year 2014, a study done by Ahmad Alghadir et al. concluded that the training program for isometrics for quadriceps was beneficial in improving strength, pain, and disability functionally [9].

Training on a vibration machine depends on frequency, vibratory stimulations, and initial strength. When the muscle is at a stretch, it reacts more sensitively to vibrational excitation and contracts more rapidly. Larger length of muscle under training generates more tension, which gives a great response to vibration. A squatting task can be useful for the recruitment of quadriceps muscle. In 2015, a study by Hamid Reza Bokaesian et al. [2] concluded that strength training in the control group gave better results in improving VAS and WOMAC scores. Adding whole-body vibration was effective in improving functional performance by increasing quadriceps activity [2].

In our study also, it was reported that whole-body vibration was effective in reducing pain and improving ranges with confidence in patients to participate better functionally in there day to day activities. WOMAC has been enhanced in the experimental group. This may be because of a training session that involved a squat position that has specific components of everyday functional movements. The squat strengthens the lower limb muscles and improves the ability to stabilize knee against a medial or lateral displacement.

A study by Jinmo(2015) et al. [17] suggested that elderly patients suffer from loss of proprioception and balance. Also, the greatest risk factors amongst the elderly for falls are muscle imbalance, decreased postural and balance control, decrease walking abilities, etc. They become progressive as age progresses, which results in a decrease in strength, power, and muscle strength in lower extremities commonly. Exercises were found to be effective for the prevention of falls in the elderly in improving balance as well as muscle strength [14].

A study by Anwar et al. (2015) [18] in lower backache patients found that whole-body vibrator activated and improved coordination in deep abdominal muscles resulting in increased muscle strength around lumbar. This even activates mechanoreceptors of non-contractile and contractile tissues in the lumbopelvic region. The above study suggests that vibration may assist in the recovery of the proprioception through improvement in muscle contraction. Further different positions assumed, such as standing, squatting will have positive effects on postural balance [19].

Whole-body vibration, along with exercises, increases walking speed and is beneficial to train for walking abilities. In our study, squat position training of the whole body on a vibration machine had given positive results for balance along with conventional exercises. The squatting exercise training, along with whole-body vibration, maybe better for executing functional movements that are required for balance as well as gait performance.

A combination of muscle-strengthening exercises of lower extremities and back can be effective in maintaining balance and walking. Strengthening is vital for quadriceps as loss of hyaline cartilage can cause loss of articular cartilage and impairment, which results in capsular damage and weakness. Weakness and joint stability are important factors to which muscle strengthening is required [20].

Whole-body vibration and strengthening exercises are effective in maintaining muscle strength by an increase in initial power generation as attributed to neural factors—increased sensitivity of stretch reflex results in muscle contractions, which is known as tonic vibration reflex. Whole-body vibration works on the mechanism of tonic vibration reflex, which causes mechanical activation of muscle spindles and neural signals by afferent nerves and muscle fiber activation by large alpha motor neurons [21].

Strengthening exercises improve weakened structures around knee joints. Quadriceps is a dynamic stabilizer of the knee joint which connects with the association of balance. Studies have suggested that whole-body vibration is effective in improving isometric torque of quadriceps muscle. Strength training was found showing benefits with either groups [22].

Gravitational load on the subject, when applied in standing position on vibration influences the neuromuscular system. It is the ability to produce muscular activities that maintain the body via the integration of afferent signals through peripheral neurons, which controls afferent signals. Use of local vibration instead of whole-body vibration did not induce any change in neuromuscular system because whole-body vibration transmits and stimulates primary nerve endings of muscle spindles which activates the alpha motor neurons and causes muscle contractions similar to tonic vibration reflex which results in improving pain, neuromuscular function, and physical function [6].

CONCLUSION

This study highlights the importance of whole-body vibration training and has seen benefits of the same with pain, disability, balance, and strength parameters with the most significant results seen in improving disability, a main cause of concern in knee osteoarthritis. Thus after determining the intensity and frequency of treatment, vibration training could be a part of regular rehabilitation protocol for knee or hip osteoarthritis patients. With limitations of less sample size and short term follow up, further studies evaluating as seen in squatting position, outcomes can be assessed with different static or dynamic positions too. In knee osteoarthritis, the effect of different duration and frequencies on the whole body vibrator for variables can also be studied. A population with hip osteoarthritis can also be undertaken.

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