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Research Article

COMPARATIVE EFFECT OF STRENGTH TRAINING AND SENSORY TRAINING OF LOWER LIMB ON BALANCE AND FUNCTIONAL MOBILITY IN ELDERLY POPULATION WITH OSTEOARTHRITIS OF KNEE - A RANDOMIZED CLINICAL TRIAL

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A B S T R A C T

Osteoarthritis (OA) is a chronic condition that causes degenerative changes around the joint. Balance impairments and increased postural sway due to reduced proprioception and strength occurs with advancing age. Hence, strength training and sensory training are important aspects of treatment in patients with knee OA.

Aim: To evaluate effect of strength training and sensory training of lower limb on balance and functional mobility in elderly population with OA knee.

Method: Participants were briefed about the study and consent was taken. 30 participants were randomly divided into 2 groups. Group A received Strength training and group B received Sensory training. Treatment was given for 3 days a week for 4 weeks. Pre and post treatment assessment was done using BBS and TUG test.

Results: Group B results are better on higher mean difference values.

Conclusions: Group B sensory training is effective in reducing the risk of fall in older population with knee OA.

INTRODUCTION

Osteoarthritis (OA) is a degenerative joint disease that mostly affects the weight-bearing joints of the body. The pathological changes associated with OA does not only affect articular cartilage, but also all joint structures. These changes together result in reduction of joint proprioception, and muscle weakness.[1]

Common complains of patients with knee OA are knee pain, joint stiffness, decreased muscle strength, and proprioceptive deficits. When OA affects weight bearing joints, mainly the knee, it shows distinct reduction of muscle function resulting in reduction of balance and especially of the ability to perform sit-to-stand tasks, gait alterations, limitation of function, and dependence. That is why, OA is observed as an intrinsic risk factor for the event of falls.[2]

Due to degenerative changes, the condition may also be accompanied by other abnormalities as in the excitability of the nerve endings around the joint tissues and abnormalities of motor activity.

Knee pain develops in the chronic stage of the disease as a result of a complex interaction between internal and external stimuli that leads to increased peripheral and central nervous system sensitivity. Pain has been found to be the major cause for reducing functional ability in knee osteoarthritis patients. Pain, effusion, joint laxity diminishes proprioceptive awareness and in the lower limb this may lead to deficits in balance. The positioning of the lower extremities during ambulation is influenced by a lack of conscious awareness of joint motion and position in the knee. In knee osteoarthritis patients, balance problems are linked to a higher risk of falling and poor mobility. Proprioception and balance are important aspects of osteoarthritis treatment because of their strong correlation with function in the knee.[3]

Functional joint stability is often assessed using balance. It is impacted by the same sensory input that mediates joint proprioception, and it is partially reliant on the ability to integrate joint position sense and neuromuscular control. Muscle strength in knee osteoarthritis patients has been shown to be an important determinant of functional ability. The periarticular knee muscles are an integrated component of the knee joint and provide knee joint movement. The muscles help govern body position and movement by absorbing stresses and loads created during walking. Adequate functional capacity necessitates sufficient muscle strength. Muscle weakness has been found to increase the risk of reduced functional ability in knee osteoarthritis patients.

The sensorimotor system relies on proprioception to maintain joint stability in the knee. Sensory receptors and mechanoreceptors can be affected by degenerative changes in OA. When sensorimotor dysfunction exists an abrupt jarring of

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the leg at heel strike will occur, initiating or perpetuating arthritic damage. The addition of sensory training techniques to exercise therapy programs can develop skills adequate to protect the knee from potentially harmful loads during functional activities.[3]

Sensory training is a special form of training designed for management of patients with chronic musculoskeletal pain syndromes. It is based on the concept that instead of emphasizing isolated strength of a group of muscles around a joint, we should realize the importance of the central nervous system in regulating movement in order to reach proper firing patterns for maintaining joint stability.[1]

Sensory retraining uses concentration and exposure to different sensory inputs to improve sensory awareness. Examples of sensory retraining techniques are discrimination of texture, shape, or weight training joint position sense object recognition activities, detection of touch, and education about the sensory loss. Safety integration with the environment, mobility quality, and rehabilitation success are all impacted by sensory deficiencies. The foot while standing and posterior thigh while sitting provide somatosensory input to the central nervous system from the environment.

In the literature and also general clinical practice sensory training of lower extremity is more focused on the feet assessment and treatment of thigh and leg sensation with balance training in patients with knee OA is neglected.[4]
So, the purpose of this study was to check the comparative effect of strength training and sensory training of lower limb on balance and functional mobility in elderly population with OA knee.

MATERIALS

1. Prickly ball
2. Band with different textures.
3. Sponges of varying hardness.
4. Percussion gun.
5. TENS

METHODOLOGY

1. Type of sampling: Simple random sampling
2. Study design: Randomized clinical trial
3. Study duration: 6 months

Inclusion and Exclusion Criteria

Inclusion Criteria

1. Male and female elderly patients of 60 years and above.
2. Patient medically diagnosed with knee OA and grade 2-3 on Kellgren and Lawrence grading system.
3. At least three of the following six clinical features: - Stiffness less than 30 min, Crepitus, Bony tenderness, Bony enlargement, No palpable Warmth.
4. Moderate to severe degenerative changes of knee joint that features: - Reduction of medial joint space, Subchondral sclerosis, Subarticular cyst formation, Marginal osteophytes, Minimal lateral subluxation.

Exclusion Criteria

1. Presence of R.A, Polyarthritis or systemic inflammatory arthropathies.
2. History of total knee arthroplasty or major knee trauma injury or deformity.
3. Corticosteroid injection to the quadriceps or patellar tendon in the last month.
4. Musculoskeletal problem like fractures, tendonitis or bursitis or any significant symptoms affecting the whole lower limb or back that would severe enough to interfere with the exercise program.
5. Use of walking aids.

Procedure

Ethical clearance was granted from the Institutional Ethical Committee. The inclusion and exclusion criteria were used to choose all of the subjects. Prior to the study the whole procedure was explained to the subjects. Male and female patients between the ages of 60 years and above with medically diagnosed OA knee were taken from tertiary care hospital. Subjects was randomly divided in two groups (Group A and Group B). Procedure was explained to the patients and a written consent form was taken from all the subjects selected. Group A was given strength training exercises and Group B was given sensory training program for the quadriceps, hamstring, calf muscles and sole of the foot for 45-50 min each session 3 days per week for 4 weeks. Assessments was conducted at baseline and after 4 weeks by TUG and BBS.[4]

Pre-Intervention Test

Berg balance scale (BBS)

Reliability – 0.97
It is 14 item scale designed to measure balance of the older adults in clinical setting.

Time up and go test (TUG)

Reliability – 0.97-0.99
This is a lower limb functional test.

Intervention

Group A: Strength Training

Strength Training Protocol

1. Quadriceps-setting exercise: Patient lying in a firm bed in supine position with the knee extended. Then the patient was asked to push the knee back and tighten the thigh muscle, causing the patella to glide proximally, and then hold for a count of ten. It was done ten times for each leg.
2. Straight leg raises: Patient lying in a firm bed in supine position and kneecap pointing to the ceiling. Then patient was asked to tighten the thigh muscle in one leg and then slowly lift that leg about 45 degrees of hip flexion while keeping the knee extended. Then after ten sec holding the leg, the patient was asked to slowly lower the leg down to the bed. It was done ten times for each leg.
3. Hamstring-setting exercise: Patient position is long sitting with the knee in slight flexion over a towel roll. The patient was asked to isometrically contract the knee flexors just enough to feel tension developing in the muscle group by gently pushing the heel into the treatment table and holding the contraction for ten sec. Then the patient was asked to relax and repeats the exercise ten times with each leg.

4. Quadriceps strengthening exercise: The patient sits on a chair. Then straighten the leg and hold for five to ten sec. and then slowly lower back the leg. It was repeated five to ten times with each leg throughout the full range of motion. Later resistance was added, if the patient does not experience pain.
5. Mini-Squat: Patient was asked to stand holding the back of the chair for balance. He or she stands with feet shoulder – width apart, then slowly bend the knees and then straighten them. At that time, he or she was instructed to keep the heels on the floor throughout the exercise. It was repeated ten times.
6. Progressive resisted exercises with weights and TheraBand in sets of 2 x10 repetitions and increments in sets per week for the leg was given.

Fig No 1 Quadriceps-setting exercise

Fig No 2 Progressive resisted exercises Thera B and

Group B: Sensory Training

Sensory Training Intervention

- The subject's knee was relocated and then returned to its original position; the subject then attempted to reposition the knee.
- A prickly ball was moved on the hamstrings, gastrocnemius and soles of the foot for touch sensation.
- Vibration was applied with a percussion gun on the quadriceps, hamstrings, gastrocnemius, soleus and sole of feet for 3-5 min.
- Sponges of varying hardness was moved on the surface of the hamstring, quadriceps, gastrocnemius and soleus.
- Sensory TENS was applied for 12 min to provide sensorial stimulus around the knee and leg muscles.
- When the training was finished, a band with different materials on it was placed around the thigh. This band stayed on the thigh until the next session.

Fig No 3 Application of percussion gun

Fig No 4 Application of TENS

Post Intervention Test

After the intervention of both groups was completed the pre intervention test BBS and TUG were repeated. Both pre and post intervention data was compared. Also, the data between the two groups was compared and the effect between the two groups was evaluated.

Statistical Analysis

Statistical analysis was performed using Statistical Package for the Social Sciences [SPSS] software 16.0. The level of significance for PRE and POST BBS and TUG Test was performed using Paired and unpaired t test.

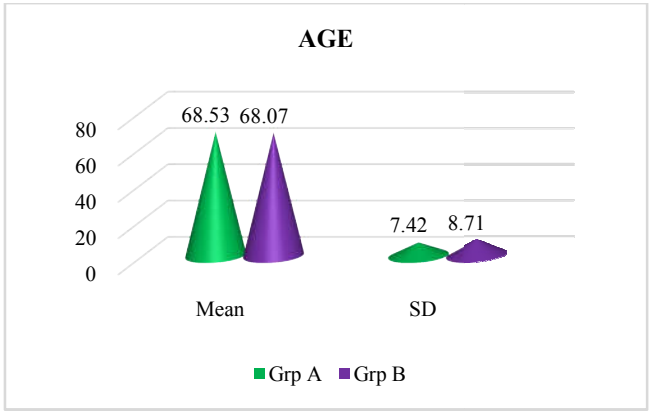
RESULTS

Data analysis was done using Statistical Package for the Social Sciences [SPSS] software. The level of significance for PRE

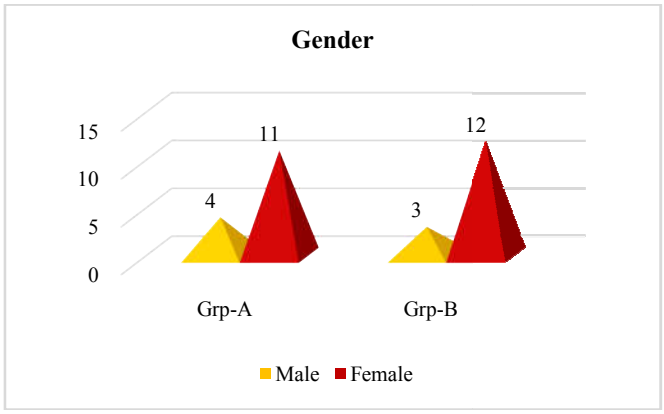
and POST test for BBS and TUG test for between group was calculated using Paired t test.

The level of significance for within group was done using Cohen's D test.

For this study, 30 participants with impaired Balance and decreased Functional mobility were included. To check the Balance and Functional Mobility, BBS and TUG test were used respectively for both the groups, pre and post the intervention.



Graph No.1 Shows Mean and Standard Deviation of Baseline Data [Age].



Graph No 2 Shows Mean and Standard Deviation of Baseline Data [Gender].

Normality test using Kolmogorov-Smirnova

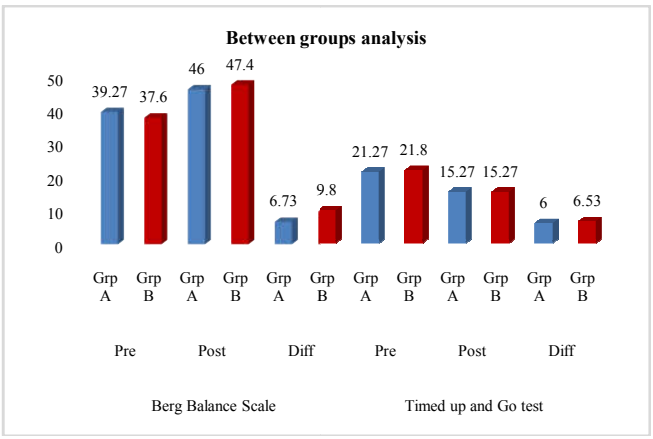
Table No 1 Shows p- value and z- value of pre and post intervention of Group A and Group B

Group	Time frame	Berg Balance Scale		Timed up and Go test	
		z-value	p-value	z-value	p-value
Group A	Pre	0.140	0.200	0.111	0.200
	Post	0.153	0.200	0.186	0.170
	Difference	0.151	0.200	0.213	0.051
Group B	Pre	0.199	0.115	0.165	0.200
	Post	0.162	0.200	0.143	0.200
	Difference	0.212	0.068	0.162	0.200

From the above within groups' analysis using paired sample t test for both groups A and B, it is observed that BBS and TUG mean value indicated changes post treatment and higher mean values are recorded for post treatment outcome and also the standard deviation shows the consistency with post treatment value which is less than pre value.

The effect size Cohen's D indicates 2.25 and 1.67 value for Group A and 2.62 and 2.85 for Group B for BBS and TUG respectively which is assumed to be very high in effect size as per the standard parameters of reference.

Thus, reference to the results of the test analysis at 5% significance level, there is a significant statistical reliable difference between the pre & post treatment values with p-value is less than the 5% significance level(i.e., 0.001 < 0.05) in the study and therefore it justifies the improvements in health outcome post intervention.



Graph no 3 Shows between group analysis for both the outcome measures BBS and TUG Test between both the groups, pre and post test respectively

Also, it is observed that between groups analysis is non-significant for both the variables across the pre & post values at 5% level significance since p-value is more than 5% level but difference value in BBS than TUG test is significant at 5% level significance since p-value is less than 5% level. Since the effect size is higher in group B then Group A higher effect size outcome shows better recovery or health improvement post intervention The final analysis proves that there is a substantial statistically significant difference between the groups across difference values and group B results are better on higher mean difference values.

This states that both techniques are effective but Group B sensory training is more effective than Group A Strength training.

Within group Pre and post paired sample t test for Group A and Group B

Table No 2 Shows Mean and Standard Deviation, Effect size, t-value and p-value of BBS and TUG within Group A and Group B.

Variable GROUP A	Pre		Post		Diff		Effect size	t –value	p –value
	Mean	SD	Mean	SD	Mean	SD			
Berg Balance Scale	39.27	6.20	46.00	4.58	6.73	2.99	2.25	8.730	0.001*
Timed up and Go test	21.27	4.92	15.27	4.11	6.00	3.59	1.67	6.481	0.001*
GROUPB									
Berg Balance Scale	37.60	6.87	47.40	5.10	9.80	3.75	2.62	10.134	0.001*
Timed up and Go test	21.80	7.01	15.27	5.30	6.53	2.29	2.85	11.026	0.001*

* Significant at 5% level

DISCUSSION

The present study was aimed at evaluating the effect of strength training and sensory training of lower limb on balance and functional mobility in elderly population with OA of knee. This study included 30 patients divided in two groups of 15 participants each. Also, this study shows a distribution of female participants more than male participants which gives an idea that females are more prone to balance issues and knee dysfunction compared to males. In this study there was inclusion of both male and female participants and assessment of Balance and Functional mobility was done by 1.) BBS and 2.) TUG test respectively. BBS was taken by assessing the ability of patients to perform functional task and TUG was used to evaluate a person's mobility.

Between groups analysis using independent sample t test

Table no 3 Shows the mean, standard deviations, z-value and p-value of both the outcome measures of pre and post intervention between both the groups, pre and post-test respectively

Variable	Time frame	GROUP	Mean	SD	z-value	p-value
Berg Balance Scale	Pre	Grp A	39.27	6.20	0.697	0.492
		Grp B	37.60	6.87		
	Post	Grp A	46.00	4.58	0.791	0.436
		Grp B	47.40	5.10		
	Difference	Grp A	6.73	2.99	2.479	0.019*
		Grp B	9.80	3.75		
Timed up and Go test	Pre	Grp A	21.27	4.92	0.241	0.811
		Grp B	21.80	7.01		
	Post	Grp A	15.27	4.11	0.001	0.999
		Grp B	15.27	5.30		
	Difference	Grp A	6.00	3.59	0.485	0.631
		Grp B	6.53	2.29		

Comparative analysis between groups using effect size outcome

Table No 4 Shows comparative analysis between Group A and Group B using effect size outcome.

Variable	Group A Effect size	Group B Effect size	Remarks
Berg Balance Scale	2.25	2.62	Group B is better
Timed up and Go test	1.67	2.85	Group B is better

* Higher the effect size outcome is better recovery or health improvement post intervention

Reduced strength is recorded in studies done on OA. Strength training exercises of lower limb is thus cost effective for prevention of fall as static and dynamic balance are both necessary measures needed for walking. Due to which ability to maintain the projection of body's Centre of mass within manageable limits of base of support is essential. So, the study proved that, Strength training is an essential element of fall prevention alongside balance. In a study, Rogind, *et al*., 1998 have investigated the effects of a physical training program, employed twice a week for three months on general fitness, lower extremity muscle strength, agility and balance and coordination of knee OA pts. The result shows significant improvement in muscle strength.[5]

Proprioceptive training has been shown to help people improv e their proprioceptive function. Proprioceptive training is an intervention that focuses on the use of somatosensory signals such as proprioceptive or tactile afferents in the absence of input from other modalities such as vision to improve proprioceptive performance. Its main objective is to improve or restore sensory and/or sensorimotor function. Although applying such a definition necessitates more scientific effort by requiring direct measures of proprioceptive function (such as psychophysical thresholds), we believe it will be useful in guiding future research aimed at using the proprioceptive sense to improve a variety of motor functions.[6]

As the association between OA and loss of proprioception muscle weakness and pain has been reported. These deficits in sensory output from knee joint affects sensorimotor function. Proprioception deficits cause a poorer awareness of the body's position in space, resulting in poor joint biomechanics during ordinary tasks, and long-term deficient biomechanics promotes joint deterioration. The neuromuscular control of the lower limbs alters as a result of alterations in proprioception, resulting in poor balance in the elderly. Proprioception and balance are inextricably linked. Proprioceptive information is transmitted by mechanoreceptors to the central nervous system, which is important for better movement control. The field of proprioception is becoming increasingly significant as the population ages. Proprioceptive functions deteriorate as a result of physiological changes associated with ageing. Regular, proper physical activity can aid in the improvement of proprioceptive functions and the reduction of the risk of falls. In the future, further studies will be needed on the content and effectiveness of various proprioceptive exercise programs.[7]

Kelly P Westlake, *et al*.; (2007) have investigated the effects of sensory –specific balance training on proprioceptive reintegration for 3 times per week for 8-week period. This study provides evidence that sensory –specific exercise improves balance and proprioception in OA patients.[8]

Ufuk Sekir, *et al*.;(2005) explored the effects of a multistation proprioceptive workout programme on functional capacity, reported knee discomfort, and sensorimotor function.[9]

In the current study the improvements of balance in study group could be due to afferent acquisition and transmission to central integration centres where propogation of an efferent neural signal to the muscle can be initiated. The use of sensory TENS and percussion gun in sensory training have found to improve sensory input to CNS thus improving sensorimotor function of knee joint. Measuring changes in postural sway during or following vibration delivered over the muscle belly or tendon is one method used to investigate the contribution of proprioceptive inputs to postural regulation and the integrity of the integrative processes within the CNS. This method directly targets the primary muscle afferents that contribute to proprioception, and it may effectively reflect a disturbance in this system.[8]

Vibration therapy causes mechanical oscillatory motions, which enhance reflex activity by stimulating the muscle spindle to generate a tonic vibratory response, according to previous research. Vibration therapy induces a rise in intramuscular temperature, according to Lee *et al*. (2018) Lee *et al*., in addition to this finding, (2018) discovered that vibration therapy promotes counter-movement jump height via increasing muscle temperature. As a result, handheld percussive massage devices could be utilised during a warm-up before physical exercise to induce higher muscle temperature (Cochrane *et al*., 2008).and muscular activation (Cochrane *et al*., 2010).[10]

As Proprioception and Balance are correlated, in this study improvements in proprioception through sensory training of

lower limb and in return improvements in BBS and TUG test at 5% significance level(i.e., 0.001 < 0.05) within groups and a significant improvement in BBS than TUG test between groups is found to be beneficial in elderly population with knee OA.

CONCLUSION

The results of the study shows that sensory training is more effective than strength training to improve balance and functional mobility of patients with OA knee.

The improvements in Group A and Group B are both significant but Group B was found to be more effective based on the effect size of the intervention on the population with knee OA.

Hence, the sensory training protocol can be widely used and can be accepted for keeping the OA knee patients active and prevent fall.

Thus, the study concludes that sensory training has significant effect on functional mobility and balance in elderly population with OA knee.

Limitations and Suggestions

Limitations

1. Proper distribution of males and females can be done.
2. The sample size was small.

Suggestions

1. More such studies on effect of sensory training protocol on knee OA patients can be done.
2. More studies to check the effectiveness of percussion gun on knee OA patients can be done to fulfil the gap of knowledge.

Aknowledgement

I take this wonderful opportunity to thank God almighty and all the "HANDS" that have helped me complete my study and make it a success. It would like to express my deep-felt gratitude to our respected Principal sir and Guide **Dr. Ronald Prabhakar** who immensely helped me, gave advice and constant encouragement regarding my study, and whose suggestion and guidance has enlightened me on this subject. Above all, I would like to thank my parents for their blessings, love, constant support, affection and encouragement.

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