# Correlation of core muscles endurance and balance in subjects with osteoarthritis knee

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## ABSTRACT

**Background:** Osteoarthritis (OA) is a chronic degenerative joint disease with a prevalence of about 29% in India. Reduced kinesthetic receptors in joint especially around the ligaments in the knee can lead to impaired proprioceptive information to an individual. Core muscle endurance deficiency leads to an increase in the loading of the knee, as well as in knee joint contact force during dynamic movement. Hence, poor core stability may be one of the contributing factors that lead to knee OA development as well as its progression. **Objectives:** The objective of this study was to find a correlation between core muscle endurance and balance in subjects with OA. **Material and Methods:** The observational study was conducted on 50 healthy, male and female subjects, age >40 years diagnosed with OA knee using convenience sampling. Subjects underwent core stability assessment consisting of plank, bilateral side bridge, Sorenson, and 60-degree trunk flexion endurance tests. Y-balance test -Lower quarter (YBT-LQ) was used to measure dynamic balance in individuals. The data were analyzed at a 5% level of significance using SPSS. Outcomes were correlated using Spearman's correlation of coefficient. **Results:** Correlation was found between YBT-LQ and plank $r = 0.402$ ($P = 0.004$), YBT-LQ and right side bridge 0.425 ($P = 0.002$), YBT-LQ and left side bridge $r = 0.490$ ($P = 0.001$), YBT-LQ and 60° trunk flexion test $r = 0.369$ ($P = 0.008$), and YBT-LQ and Sorenson test $r = 0.324$ ($P = 0.022$). **Conclusion:** There is a weak to moderate correlation between core endurance and balance in subjects with OA knee.

**KEY WORDS:** Osteoarthritis Knee; Core Muscles Endurance; Dynamic Balance; Y-balance Test-lower Quarter

## INTRODUCTION

The term osteoarthritis (OA) implies a chronic degenerative disorder of joint whose etiology can be multifactorial. It is characterized by swelling, softening and fissuring followed by the destruction of articular cartilage, hypertrophy of underlying bone, and osteophytes formation followed by subchondral sclerosis while loose flakes of cartilage incite synovial inflammation and thickness of joint capsule also may occur.[1] Knee OA mainly targets the old population which causes pain and specially-abled individual to perform his or her functions with increased risk factors for fall injuries.[2] The most common involved weight-bearing joint in India is knee with the prevalence of OA knee in the elderly varying from 26% to 63% depending on age and gender.[3] Clinical manifestations of patients with OA knee are swelling, pain particularly after prolonged weight bearing tasks, instability (locking), and stiffness especially morning which is mainly after the inactivity. Knee OA is the last end result of various disorders leading to joint failure.[1]

Proprioception is the collective and progressing neural information that senses the position of all body segments and

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changes during the motions. It simultaneously provides this information to the higher centers of brain. There are muscular and articular mechanoreceptors which provide body and joint motion position idea.[4] Balance or proprioception may be affected in individuals with OA knee.[3]

Spine, abdominal, pelvic girdle, and proximal lower extremities are defined as part of the core of the body. The core is constructively a muscular box in which diaphragm is on the top, the pelvic floor and hip girdle musculature as the bottom, abdominals in the anterior, and the paraspinal and gluteal muscles behind.[5] Mainly core stability refers to supporting and stabilizing the spine during static and dynamic phasic alterations.[6] The core is the central link which provides linkage between upper and lower extremities function.[6] Core stability is requisite for optimal functioning and injury prevention. All the hip musculatures have their origins in pelvic and lumbar regions so that the compromised core can be responsible for an unstable proximal base which mainly works to influence higher centers to elicit appropriate combinations and quality muscle recruitments for stability as well as mobility.[7] Thus, ultimately it limits the control and positioning of the lower extremities for functional movements and increases load and injury risks.[7]

Dynamic balance refers to the potential reactions of the motor system where an individual is able to cope with the quick alterations of body segments while performing activities that add stress on the knee joint. Dynamic stability is the ability of the body to maintain position or intended posture after external or internal disturbances. An erect posture is controlled by the neuromuscular kinesthetic senses which also checks for any alteration or the shift in the involved parts as well as torso at the time of the function. Hence, in patients with OA knee who already have compromised proprioceptive senses, this furthermore can be aggravated due to weak core musculature. Studies have supported that compromised proprioceptive control of the torso or core musculature can be the major risk factor affecting the dynamic stability of the lower extremities which mainly affects weight-bearing patellofemoral and tibiofemoral joints.[5]

There are many studies supporting the relationship between knee pathology and core stability deficits and balance deficits, but there are few studies establishing a correlation between the core muscles endurance and dynamic balance in subjects with OA knee. Therefore, this study was conducted with the aim to find a correlation between core muscle endurance and balance in subjects with OA of the knee.

## MATERIAL AND METHODS

An observational analytical study was conducted on 50 subjects with OA in the Physiotherapy Department of V.S. General Hospital, Ahmedabad. Permission from the head of the institute to conduct the study was taken. Both male and female subjects, age >40 years diagnosed with unilateral or bilateral OA knee by orthopedician according to the American College of Rheumatology criteria were recruited from the general hospital using convenience sampling. Subjects with cardiovascular respiratory disorders, lower limb surgery, any condition affecting lower extremity function, altered limb length, and inability to walk or climb a staircase without assistive devices were excluded. Patients who fulfilled the inclusion criteria and gave informed consent to participate were included in the study. If any subject wished to withdraw from the study at any time, they were allowed to do so. An assessment form was filled containing the patient data about personal characteristics: Age, occupation, any associated medical condition, drug history, and measurement of weight and height for the body mass index (BMI).

Before the core stability test and dynamic balance measurement, all subjects were given a demonstration on how to carry out the test correctly. A single trial was given for each test, to familiarize participants with the technique and procedure. A 3–4-min resting period was given between each core stability test to ensure all the muscles involved had enough recovery time, to avoid fatigue. In addition, subjects were encouraged to put in their maximal effort in each test. Core stability was assessed using the isometric core muscular endurance test.[2] Patients were asked to hold a specific static position for as long as possible according to the objective of the endurance test. The first isometric test was assessed using the Plank test. This was followed by another three tests which were using protocols established by McGill *et al*.[2] including the trunk flexion test, trunk extension test, and bilateral side bridge tests. Dynamic balance was assessed using Y-Balance Test Lower Quarter (YBT-LQ)[8] (Intraclass correlation coefficient inter-rater test reliability 0.85–0.93 intrarater test reliability.0.67–0.96).[9]

### Plank Test [Figure 1]

The participant was asked to lay down with face downward, raised upper body, stabilized by the elbows; hips and legs elevated off the floor and asked to maintain straight body alignment from shoulder up to the ankle through hip, knee, and ankle when the body is held up by forearms and toes

**Figure 1:** Plank test

with elbows 90° flexed under the shoulders and ankles at 90° with spine in neutral position. The participants were asked to maintain the position of the torso and timing was measured using the stopwatch. The participants were given a maximum of two trials to regain the position after that if a participant was unable to do so, the timing was stopped and noted in seconds.

**Bilateral Side Bridge Endurance Test [Figure 2a and b]**

The participant was asked to lay in side-lying position on the plinth or mat with a lower foot placed behind the upper one with knees extended. The participant held the torso off the plinth supported by the lower elbow and feet. They were asked to maintain the position of the torso and timing was measured using the stopwatch if the hip returned to the mat, the timer was stopped and noted in seconds.

**Trunk Flexion Endurance Test [Figure 3]**

The participant was asked to lay in a crook-lying position on the plinth with trunk positioned and supported at 60 degrees of trunk flexion while hips and knees are at 90 degrees of flexion with arms crossed over the chest and feet on the plinth. For the endurance test, support of the trunk was removed and the participant was asked to hold the position as long as one can. If a participant was unable to do so; the timing was stopped and noted in seconds.

**Trunk Extension Endurance Test [Figure 4]**

The participant was asked to lay in prone-lying position while pelvis, hips, and knees were stabilized to the plinth by stabilization belts. The trunk and upper extremities were supported using a vestibular ball directly in front of the body. Then, the participant was asked to hold a horizontal body position for as long as possible with arms crossed over the chest after the vestibular ball was removed. If a participant was unable to do so, the timing was stopped and noted.

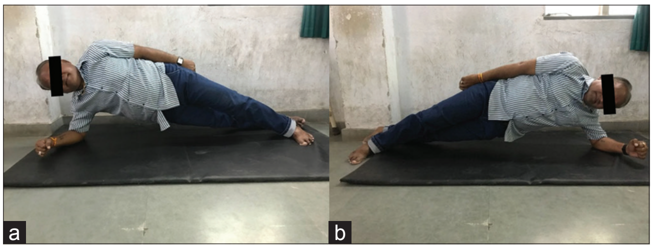


**Figure 2:** (a) Right side bridge, (b) left side bridge

**Figure 3:** 60° trunk flexion test

**YBT-LQ[8] [Figure 5]**

The dynamic postural control of body segments during the YBT-LQ is distance covered in all three directions.[10] YBT-LQ is a reliable test that assesses lower extremity as well as trunk kinesthetic proprioceptive control while maintaining single limb dynamic postural control.[7]

The patient was asked to kick a ball according to the preference of their leg dominance. The leg length of that particular lower extremity from anterior superior iliac spine to medial malleolus in supine lying was taken. The patient was asked to stand on the Y center point. For the left side, YBT-LQ patient stood on his/her left extremity and was asked to try to reach in all three directions that are anterior, posteromedial (PM), and posterolateral (PL) reach direction by slight forward flexing trunk raising the hands in scaption motion and flexing the weight-bearing extremity. Three readings for each direction were taken, and at the end, the maximum reach direction value for each direction was considered. Then, for a score of YBT-LQ, the following formula was used.

**Figure 4:** Sorenson test

**Figure 5:** Y-balance test-lower quarter in anterior, posteromedial, posterolateral reach direction

YBT-LQ = (sum of max each reach direction/3*limb length)*100.

The average score of each right and left extremity YBT-LQ score is taken for further analysis.

**Statistics**

All subjects completed the study. The data were analyzed at a 5% level of significance using SPSS. Outcomes were correlated using Spearman's correlation of coefficient. Mean and SD of demographic detail of 50 participants include mean age of 58.66 (8.90) and mean BMI of 26.45 (4.27). Among 50 participants 62% were females.

## RESULTS

Table 1 shows the demographic details of 50 participants. Table 2 shows the mean and SD of outcome measures. Table 3 shows the correlation between core muscle endurance tests and YBT-LQ.

## DISCUSSION

The present study found a statistically significant low positive correlation between all outcome measures. In the present study, it is also seen that the endurance of core stability muscles is reduced and balance is also affected in subjects with OA knee. Correlation was found between YBT-LQ and plank $r = 0.402$ ($P = 0.004$), YBT-LQ and right side bridge 0.425 ($P = 0.002$), YBT-LQ and left side bridge $r = 0.490$ ($P = 0.001$), YBT-LQ and 60° trunk flexion test $r = 0.369$ ($P = 0.008$), and YBT-LQ and Sorenson test r = 0.324 ($P = 0.022$).

In this study, a significant mild-to-moderate correlation was found between balance and core muscle endurance in subjects with OA knee. Daud *et al*. concluded that poor core muscle endurance indicates a weak core muscle which is supporting the body weight. Core muscle endurance deficiency can lead to an increase in the loading of the knee, as well as in knee joint contact force during dynamic movement.[2] OA causes patients to gradually withdraw from any physical activity due to chronic pain and structural problems. Reduction in physical activity will potentially also lead to core muscle weakness over time due to muscle disuse.[2] Having sufficient proximal stability would reduce the stress load over the patellofemoral joint. Individuals with good proximal trunk postural control will automatically reduce loading on the knee joint.[5] Hence, the occurrence of a smooth and stable movement of the lower extremities is maintained by the core musculature.[5] Jae-Seop Oh *et al.* reported that women with sustained knee ligament injuries have deficits in core neuromuscular control when compared with the normal women. Each degree increase in absolute error for active trunk repositioning equates to a 2.9-fold increase in the odds ratio for a knee injury. Knee injury status was predicted with 90% sensitivity and 56% specificity by active proprioceptive repositioning, and trunk displacement predicted knee injury with 83% sensitivity and 63% specificity.[10]

Dynamic postural control creates, transfers and maintains force and movements of the distal kinetic segmental chain which is mainly conducted through the core stability which in turn can be gained by the dynamic trunk control. Core muscles were found consistently activated before any limb movements.[2] Hodges and Richardson reported in their study that in any uniplanar or multiplanar activity of the lower extremity the transversus abdominis (TrA) muscle is the first muscle that was active in which TrA and oblique abdominal muscles were consistent throughout all movement directions wherein rectus abdominis and multifidus muscles reaction time were not consistent with the direction of the movement.[11]

In the present study, the balance was found to be affected in the subjects with OA knee. YBT-LQ dynamic balance test measures the individual's ability to cover the distance and extending his/her center of gravity over the base of support in all three directions that are anterior, PM, and PL.[4] Alim reported in their study that altered reaching distances of YBT-LQ can be due to increased abduction and adduction torques at knee joint in female participants.[4] Ohkoshi *et al*. reported that in the standing position there is increased

**Table 1:** Mean and SD of demographic details

| Variables | Mean±SD |
|---|---|
| Age (years) | 58.66±8.90 |
| BMI (kg/m$^2$) | 26.45±4.27 |
| Gender (Females) % | 62% |

SD: Standard deviation, BMI: Body mass index

**Table 2:** Mean and SD of outcome measures

| Outcome measures | Mean±SD |
|---|---|
| Plank (s) | 9.89±6.10 |
| Right side bridge (s) | 4.82±4.59 |
| Left side bridge (s) | 4.91±5.97 |
| Sorenson (s) | 3.29±5.66 |
| 60° trunk flexion (s) | 8.9±5.33 |
| YBT (% LL) (cm) | 65.26±12.90 |

SD: Standard deviation, YBT: Y-balance test-lower quarter

**Table 3:** Correlation of core muscles endurance test duration with YBT-LQ

| Outcome measures | Spearman's correlation coefficient (r) | P value |
|---|---|---|
| Plank-YBT | 0.402 | 0.004 |
| Right side bridge –YBT | 0.425 | 0.002 |
| Left side bridge –YBT | 0.490 | 0.000 |
| 60° trunk flexion test –YBT | 0.369 | 0.008 |
| Sorenson –YBT | 0.324 | 0.022 |

YBT: Y-balance test-lower quarter

hamstring muscle fibres contractility as the trunk angle increases. In dynamic balance YBT testing, knee flexors must eccentrically contract to resist the trunk movement as subject leans forward and backward to maintain their balance. Furthermore, knee flexors are the one which allows a greater YBT reach distance when subject leans forward to backward motion.[12] In their study, a significantly strong relationship was noted between knee flexor strength and performance in all three directions.[12] However, hamstrings strength was not assessed in the present study, but OA patients do complain of pain in the popliteal fossa. Lower limb muscle strength is related to core endurance. In subjects with OA knee, knee muscles may get weak and thus affect core endurance.[13] It can be said that the stability of the core musculature is responsible for optimizing the functioning/performance of lower extremity and improved balance.

Higher obesity level has been associated with poor core muscle endurance in subjects with OA knee. This result is consistent with research findings that the higher BMI increases loading on the core muscles.[2] However, BMI was not correlated with core endurance in the present study but could be a factor leading to poor endurance and knee pain.

Similar to the present study, the study of core-stability training by Kahle and Gribble reported that, as compared with a control group, maximum reach distances on the SEBT improved in healthy participants after 6-week core stability–training program. Furthermore, the strength and recruitment of the trunk musculature had improved that may have activated the core muscles and perhaps led to greater reach distances post-test. Since greater control rather than strength was the focus of their intervention, the improvements in PM and PL may have been due to enhanced neuromuscular control and dynamic balance.[14]

The limitations in the present study are that confounders such as the severity of OA on X-ray, pain, and obesity were not taken into account. Analysis of the difference between unilateral and bilateral OA and analysis of foot posture was also not done.

## CONCLUSION

There is a weak to moderate correlation between core endurance and balance in subjects with OA knee. According to the present study, there is weak core muscle endurance in patients with OA knee which may cause difficulty in maintaining dynamic balance in activities of daily living. Hence, core muscle endurance exercises can be included in the treatment protocol To see the effect on the dynamic stability in subjects with OA knee. In future correlation of pain intensity with core muscles endurance and dynamic balance also can be done. The effect of core endurance training on balance in patients with OA knee can be done.

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