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Correlation of Ankle Joint Position Sense (JPS) and Foot Posture Index (FPI) with Severity and Functional Disability in Individuals with Knee Osteoarthritis

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Abstract: ***Background: Osteoarthritis (OA) is the second most common musculoskeletal problem after backache. Knee OA causes significant alteration in foot posture and ankle proprioception. The resultant changes in knee and ankle can progress with the progression of the disease and contribute to functional disability in the elderly. Methods: 30 individuals aged 40-70 years were included in the study. Radio-graphically confirmed cases of knee OA (Kellgren-Lawrence scale) were evaluated for Foot Posture Index (FPI), ankle Joint Position Sense (JPS) and functional disability (WOMAC). Bubble inclinometer used in this study for assessing ankle JPS did not have an established reliability. Hence, a preliminary study was conducted with 25 individuals to assess intra-rater reliability of bubble inclinometer. Results: There was a positive correlation of ankle JPS and FPI with functional disability (r=0.5222, r=0.9644 respectively, p value <0.05) but no significant correlation was found with severity of knee OA (r=0.2083, r=0.2811 respectively, p value >0.05). Intra-rater reliability of bubble inclinometer was found to be 0.872 (ICC at 95% CI) (0.659-0.948) which is suggestive of good to excellent reliability. Also, observed was an extremely significant positive correlation between Foot Posture Index (FPI) and ankle Joint Position Sense (JPS) (r=0.6354, p value<0.05). Conclusion: Thus, it can be concluded that altered foot posture and ankle JPS is a contributory factor to functional disability but does not show a linear relationship with progression or severity of disease. Bubble inclinometer can be used as an effective tool for assessing proprioception at ankle.***

Keywords: Osteoarthritis, Foot Posture Index, Ankle Joint Position Sense, Kellgren-Lawrence scale, Functional Disability

1. Introduction

Osteoarthritis is defined as degenerative, non-inflammatory joint disease characterized by destruction of articular cartilage, with evidence of accompanying peri-articular bone resorption resulting in sub-chondral bone sclerosis and attempted new bone formation in the form of osteophytes. [1] Due to its chronic nature, OA is a leading cause of disability in the elderly. In females there is an increased involvement of knee and hand joints. In contrast, men have an increased prevalence of hip OA. [2] The 2010 Global Burden of Disease Study reports that the burden of musculoskeletal disorders is much larger than estimated in previous assessments and accounts for 6.8% of DALYs (Disability Adjusted Life Years) worldwide. [3] OA is a common condition with a prevalence of 22% to 39% in India. [4], [5]

OA is a multifactorial entity because it is not only the cartilaginous tissue which is involved but also other non-cartilaginous structures like the joint capsule, synovium, sub-chondral bone, ligaments and peri-articular muscles. [6]As the disease advances, these structures are affected and changes which include bone remodelling, osteophyte formation, weakening of peri-articular muscles, laxity of ligaments, and synovial effusion can become evident. OA is a chronic low grade inflammation characterized by synovial effusion which is seen in early as well as late stages of arthritis. [7]

EULAR evidence-based recommendations for the diagnosis of knee osteoarthritis includes knee pain for most of the days in the prior month in addition to three symptoms (persistent knee pain, limited morning stiffness and reduced function) and three signs (crepitus, restricted movement and bony enlargement) for clinical diagnosis of knee OA. It also estimated that probability of having radiographic knee OA increased with increasing number of positive features, to 99% when all six symptoms and signs were present. [8]

As knee osteoarthritis (OA) continues to progress, the alignment of lower extremity also continues to change. In response to loading during weight bearing, cartilage in healthy knees demonstrate adaptations in morphology and mechanical properties, causing certain regions of the cartilage to accommodate well to loading, while other regions are less well suited. Alterations in normal knee kinematics, shift loading from those cartilage regions adapted for loading to regions less well suited. This leads to the initiation and progression of degenerative processes consistent with knee OA thus contributing to uni-compartmental medial knee joint arthritis. [9]

As the severity of knee OA increases, mechanical alterations in the lower extremity also increase which in turn favours progression of the disease. This in turn may lead to compensatory changes in the lower limb including ankle-subtalar joint complex. Such mechanical changes at ankle-subtalar joint complex contribute to altered foot posture in individuals with knee OA. Studies conducted previously have shown that patients with medial compartment knee OA have a more evertedcalcaneum in the frontal plane and higher scores

of FPI (indicating pronated foot posture). [10], [11] However, there is dearth of literature on the association of foot posture with severity of osteoarthritis i.e. how progression of OA is associated with changes in foot posture is unknown.

Farrokhi et al (2016) stated that patients with knee OA reported more pain and difficulty compared to the asymptomatic population, with functional activities like prolonged sitting, ascending and descending stairs, walking, squatting, rising from a chair and kneeling.[12] Ultimately these limitations lead to loss of functional independence, decrease in muscle strength, proprioception and balance.[13] Though, altered foot posture can also contribute to the functional disability reported in patients with knee OA, the relationship between the two has not been studied. Thus, the first primary objective of the present study was to correlate foot posture using Foot Posture Index (FPI-6) with severity of knee osteoarthritis (using Kellgren-Lawrence scale) and functional disability (using WOMAC scale).

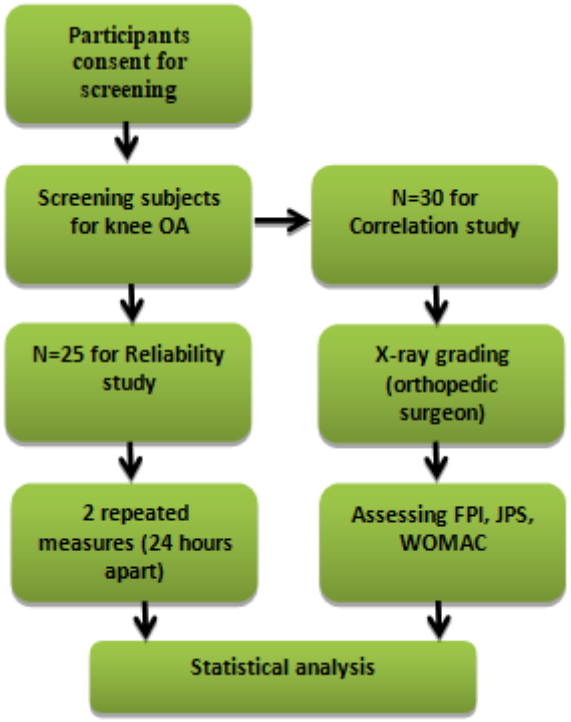
With constantly changing alignment of lower extremity, input from proprioceptors (eg. Knee, ankle) also diminishes, which in turn affects ankle Joint Position Sense (JPS) in individuals with knee OA.[14]Proprioception refers to information sent by afferent receptors from peripheral muscles, capsules, ligaments and joints to the central nervous system that contributes to efficient neuromuscular control of movement and joint stability.[15] Proprioception is studied by assessing Joint Position Sense (JPS) which is determined by measuring the accuracy of joint angle replication. In a study conducted in 2012, S.R.S Bagul stated that ankle proprioception was affected in patients with knee OA.[14] However, the extent to which this affection can interfere with day to day activities or how ankle proprioception can be affected with severity of this disease is still unclear. Hence, the second primary objective of this study was to correlate ankle JPS (using bubble inclinometer) with severity of knee osteoarthritis (using Kellgren-Lawrence scale) and functional disability (using WOMAC scale).

To our knowledge, the reliability of bubble inclinometer for assessing ankle JPS has not been demonstrated, thus the study also aimed to establish the test-retest (intra-rater) reliability of bubble inclinometer for assessing ankle JPS in non-weight bearing position. The changes in foot posture might affect the afferent input from the mechanoreceptors and thus affect ankle joint position sense, hence, the secondary objective was to examine the relationship between foot posture and ankle JPS.

2. Methodology

This analytical, cross sectional study was conducted at a tertiary health care centre over duration of 6 months. Males or Females of 40-70 years of age, with unilateral symptomatic knee osteoarthritis, having knee pain for more than 1 month and giving their consent were included. People with rheumatoid arthritis, inflammatory arthropathies, neoplasms, pain score (VAS) of more than 7 on 10, lower limb fracture, knee surgery in past 12 months, intra articular steroid injections into the knee in the past 3 months, congenital deformity of ankle, ankle sprain, ligament insufficiency of ankle or knee, neurologic conditions (hemiplegia, quadriplegia, parkinsons, cerebral palsy, peripheral neuropathy) and who were wheelchair bound were excluded. Following calculation of sample size, 30 individuals were selected by consecutive sampling method. The research topic was approved by Institutional Ethics Committee. Participants were screened for knee osteoarthritis, radio-graphically confirmed and graded as per the Kellgren-Lawrence scale. WOMAC questionnaire was completed by each participant in their vernacular language and scored by the investigator. Foot posture was assessed using FPI, graded in numerical units and ankle JPS was assessed using bubble inclinometer, measured in degrees. However, as reliability of bubble inclinometer for measuring ankle JPS was not documented,hence, the researcher also assessed intra-rater reliability of bubble inclinometer in non-weight bearing position for ankle and found that ICC (95% CI) was 0.872 (0.659-0.948) which is suggestive of good to excellent reliability.

Study Layout



Ankle Joint Position Sense (JPS): Since gait cycle includes both weight bearing (WB) and non-weight bearing (NWB) phases (stance and swing) there is justification of both WB and NWB proprioception assessment. Also, it is generally accepted that active Joint Position Sense tests produce better results than passive tests (Crake and Crawshaw 1975, Velay et al 1989). Hence in current study proprioception was assessed actively in NWB position.

FIG 1: STARTING POSITION

FIG 2: END POSITION

Subject was blindfolded and in a high sitting position with thigh fully supported, knee flexed to 90 degrees and foot off the ground. Foot was placed off the supporting surface in zero degree of inversion, eversion, plantar-flexion, dorsiflexion. Therapist brought the patients foot to neutral and then foot was moved to 15° of plantar-flexion. This position was held for 15 seconds and then foot was actively moved into varying degrees of plantar and dorsiflexion. Following this, subject was asked to actively position the foot into 15° of plantar flexion. Before starting the movement, bubble inclinometer was placed on dorsal aspect of foot along third metatarsal. Three readings were taken and difference between initial and final angle was noted and an average absolute error of these three readings was used for analysis. To assess intra-rater reliability of this instrument, a repeated measure was taken after 24 hours to avoid any recall bias.

3. Results

The data was entered using Microsoft office 2010 and analyzed using GraphpadInstat version 3.10 Biostatistics software. Intra-rater reliability of ankle JPS with bubble inclinometer was assessed and Intra-class Correlation Coefficient at 95% Confidence interval (ICC at 95%CI) was calculated using SPSS software version 24. Descriptive analysis of numerical data was expressed in mean ± standard deviation,median, frequency of categorical data was expressed in percentage. Normality of data was assessed using the one sample Kolmogorov-Smirnov test. Age, BMI, ankle JPS, WOMAC values were normally distributed whereas FPI and Kellgren-Lawrence scale were not normally distributed. Hence, Pearson correlation test was used to correlate ankle JPS and WOMAC score while all other components were correlated using Spearman's correlation coefficient. P-value less than 0.05 was considered statistically significant.

Table 1: Descriptive statistics of demographic data and Outcome measures

DATA	MEAN ± SD	MEDIAN
AGE (YEARS)	57.1 ± 9.614	59.00
BMI (KG/M^2)	27.98 ± 4.808	27.20
KELLGREN-LAWRENCE SCALE	2.5 ± 0.78	2.00
WOMAC SCORE	51.63 ± 9.31	54.50
JOINT POSITION SENSE (AVRAGE ABSOLUTE ERROR)	2.63 ± 1.64	2.67
FOOT POSTURE INDEX	6.87 ± 2.43	7.50

Table 2: Descriptive statistics for Gender

GENDER	FREQUENCY DISTRIBUTION
MALES	8 (26.66%)
FEMALES	22 (73.33%)

Table 3: Intra rater reliability for ankle Joint Position Sense (JPS) using bubble inclinometer

ICC	95% CI	P value
0.872	0.659-0.948	0.0000

Graph no.1: Bland-Altman analysis plot for ankle Joint Position Sense (JPS) using bubble inclinometer. The solid line indicates the mean difference (d=0.439), dashed line mark mean difference ±1.96 SDs. Dots represent the 25 ratings in the study population.

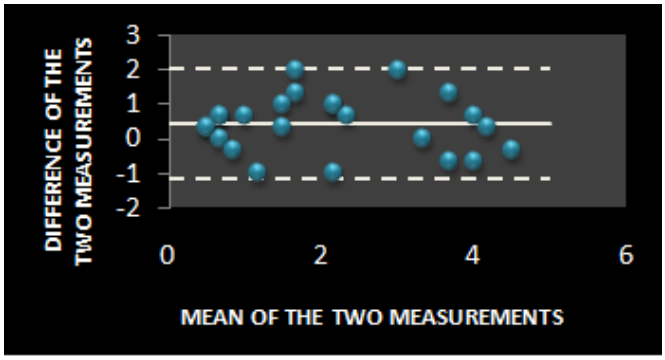


Table 4: Correlation analysis of Outcome measures

COMPONENT	CORRELATION COEFFICIENT	P VALUE	SIGNIFICANCE
ANKLE JPS AND KELLGREN-LAWRENCE SCALE	0.2083	0.2694	Not significant
ANKLE JPS AND WOMAC SCORE	0.5222	0.0031	Very significant *
FPI AND KELLGREN-LAWRENCE SCALE	0.2811	0.1325	Not significant

FPI AND WOMAC SCORE	0.9644	<0.001	Extremely significant *
FPI AND ANKLE JPS	0.6354	0.0002	Extremely significant *

*Correlation is significant at p< 0.05

4. Discussion

There is ample published literature which reveals affection of foot posture in individuals with knee OA. Foot pronation is the most common posture seen in these individuals.[11], [16], [17], [18] Also, in knee osteoarthritis, lower extremity mechanical alterations affect proprioceptive input from ankle and hence contribute to alteration of ankle JPS.[14], [19] As these facts are already established, current study was conducted with the primary objective to study the relationship between ankle proprioception (JPS) and foot posture (FPI) with radiological severity (Kellgren-Lawrence scale) and functional disability (WOMAC score) in individuals with knee OA. The secondary objectives of this study were to study the correlation between foot posture (FPI) and ankle proprioception (JPS) in individuals with knee OA and to establish reliability of bubble inclinometer for assessing ankle JPS in individuals with knee OA.

Current study established a significant positive relationship between affection of ankle proprioception (JPS) and functional disability (WOMAC) in patients with knee OA. Numerous changes take place at ankle-subtalar joint complex, which may be attributed to deviations in ankle joint alignment, secondary to structural changes at the knee, in subjects with knee OA. [20], [21] A study conducted by Hubard et al (2010) reported that as knee OA continues to progress, the alignment of the lower extremity also continues to change because of the abnormal contact pressures that develop within the medial and lateral compartments of the tibio-femoral articulation.[20] The mechanical stability changes (i.e decreased antero-posterior displacement and inversion-eversion at ankle, alteration in the axis of rotation at ankle joint) are likely to manifest into larger kinematic changes occurring at the ankle-subtalar joint complex that will certainly impair overall gait (either during level walking or on stairs) and other daily functional activities.[22] These mechanical alterations will also impair proprioceptive input from ankle joint.[14], [19] Sharma et al.[23] observed that impaired proprioceptive sense had negative effects on functional parameters such as walking rhythm, shortened distance of step, and decreased speed of walking. Henry et al [24] observed increased postural sway in patients with knee OA, which may be due to impaired proprioceptive input from ankle mechanoreceptors, muscle spindles, and the cutaneous receptors of the foot, which make important contributions to the maintenance of static postural control. As knee OA results in affection of ankle proprioception, which can contribute to postural stability and therefore to daily function, it can be inferred that affection of ankle JPS will increase disability in knee OA patients.

Aala et al proved that there is a significant effect of pronated foot posture on Arabic WOMAC (Ar-WOMAC) physical function subscale while no significant effect was found in the other two subscales (pain and stiffness) of the Ar-WOMAC index. [25] This is in accordance with the results of the current research which is suggestive of a significant correlation between foot posture (FPI) and functional disability (WOMAC). As foot pronation increases, foot mobility increases and its adaptability in weight bearing position increases. However, this is associated with a decrease in stability thereby contributing to functional impairment, increase tendency for falls and resultant functional disability.[26]Guler et al. observed that coexisting foot deformities, including flat feet, increase the disability in women with knee OA. [27] In clinical practice, these foot deformities are preventable/ correctable and hence need to be worked on at a stage of primordial and primary prevention.

Foot pronation is the most common type of posture seen in individuals with medial compartment knee OA. The altered rear-foot posture of pronation in patients with knee OA appears to be a compensatory response to the kneevarus alignment, to allow the foot to be plantigrade. [28] Norton et al. observed that relationship of the mechanical axis and hind-foot valgus angle was stronger in severe varus mal-alignment while it was weaker in patients with a milder varus mal-alignment. [29] The authors further emphasized that significant relationship of the correctedAnatomical Axis Angle (AAA) with the calcaneus angle relative to the floor indicated that the calcaneus angle might be more sensitive to the altered frontal plane alignment rather than mid-foot/forefoot alignment. Navicular height and navicular height/foot length, two of the mid-foot alignment measures, were not significantly associated with the corrected AAA. Navicular height in patients with knee OA is similar to that in healthy adults, even in patients diagnosed to have a pronated foot according to foot posture index and arch index. [30], [31] Thus, much of the published literature supports the concept that patients with knee OA have pronated foot, however this rear-foot compensation might not be sufficient alone to result in a progressive pronation with progressing severity of knee OA. Pronation also includes components of mid-foot and rear-foot which are not strongly associated with varus deformity. This might be the reason why a linear association between pronated foot posture and severity of knee OA could not be established in this study.

The factors mentioned above, affect mechanical alignment causing resultant changes at ankle-subtalar and foot complex and thus affect ankle proprioception. [14], [19] This is seen because the input from ankle and foot receptors to the higher centres will be compromised due to the mechanical changes at the ankle foot complex. [19] However, compensatory changes at the hind-foot, mid-foot and forefoot are not consistent with progression of the disease hence resultant proprioceptive input (ankle JPS) from proprioceptors may not correlate linearly with severity of the disease as seen in this study. On extensive review of literature, this seems to be the first study correlating ankle JPS with severity of knee OA and the results do not support a linear relationship between affection of ankle JPS and severity of disease.

The most common foot posture observed in patients with mild to moderate knee OA is normal to pronated foot. [10], [11], [30] This everted and pronated foot posture occurs because of weakness and inadequate muscular stabilization which results in splaying of foot. Excessive pronation results in flattening

of medial longitudinal arch and hypermobility of mid foot. This places greater demands on the neuromuscular system to stabilize the foot and maintain upright stance. [32] As a result of these changes, the cumulative neural input from mechanoreceptors located in the joint-capsule, ligaments, muscles, tendons, and skin is affected which contributes to affection of proprioception at ankle joint. This is evidenced by the significant positive correlation between foot posture (FPI) and ankle proprioception (JPS) observed in current study.The proprioceptive mechanism is essential for proper function of the joint in sports, for activities of daily living, and for some occupational tasks. [32] Aydin et al stressed on assessment of proprioceptive sensibility as it is valuable for identification of proprioceptive deficits and for subsequent planning of a rehabilitative program. [33]

5. Limitations

The study had certain limitations since randomization was not performed for selection of the sample and foot pain was not considered in the study.

6. Conclusion

It can be concluded that affection of foot posture and ankle JPS is a contributory factor to functional disability but does not show a linear relationship with progression or severity of disease in individuals with knee osteoarthritis. Also, affection of foot posture has positive relationship with affection of ankle JPS. Bubble inclinometer can be used as an effective tool for assessing proprioception at ankle joint.

Clinical Implication: In individuals with knee OA, evaluation should not be restricted to knee joint, but should also include assessment of ankle-foot complex. Closed kinetic chain exercises should be incorporated at an early stage for individuals with knee arthritis to enhance proprioception. Also, corrective orthosis (eg wedges or insoles) should be included in rehabilitation at an early stage. While planning a rehabilitation protocol, attention should not only be directed towards radiographic severity of the disease but also to functional evaluation.

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