"ANALYSIS OF DIFFERENCES IN THE GAIT PARAMETERS IN PATIENTS WITH VARYING GRADES OF KNEE OSTEOARTHRITIS USING 3D GAIT ANALYSER"

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ACCEPTANCE LETTER

The softcopy of thesis entitled: **"ANALYSIS OF DIFFERENCES IN THE GAIT PARAMETERS IN PATIENTS WITH VARYING GRADES OF KNEE OSTEOARTHRITIS USING 3D GAIT ANALYSYLER."** has been submitted for Anti-Plagiarism check through Turnitin software. The scan has been carried out and the scanned output reveals a match percentage of **08%** which is within the acceptable limits of **10%** as per the guidelines given by UGC.

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ABSTRACT

Background: Osteoarthritis (OA) is the most common degenerative disorder usually pronounced as gradual destruction of cartilage, affecting multiple joints especially the weight-bearing joints like the hip joints and knee joints. It has impact not only on the involved joint but also affects the other joints and invariably affects the gait of the individual. Though, the variability in the gait among the cases with osteoarthritis of knee was already assessed by several researchers, there are variations which occur with respect to age of the population and their ethnicity. Thus this study was performed to determine the differences in the gait parameters among cases with history and varying grades of knee osteoarthritis using 3d gait analyzer.

Methods: A cross sectional study was conducted in the department of Orthopedics in KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belagavi, among the cases with osteoarthritis knee attending outpatient and inpatient department of Orthopedics during January 2020 to December 2020. A total of forty patients with osteoarthritis of knee joint were included in this study. Ethical committee approval was obtained for this study. After taking the written informed consent all the study participants were assessed for their demographic and clinical presentation by the principal investigator using a pre structured proforma. Following which the principal investigator assessed the detailed history of the participants from their parents and clinical examination was done. Also all the cases underwent bilateral knee X rays (both anterior and posterior views) and their entire gait parameters were assessed using 3D gait analyzer. All the reports from both cases and controls were entered in the same proforma where clinical presentation was entered by the principal investigator. Data was

analyzed using SPSS (Version 19). To test the hypothesis Mann-Whitney U test and Chi Square test was used.

Results: Varus deformity was noted in 60% of the cases and valgus deformity in 40% of cases. Based on the Kellgren Lawrence scale x ray findings of knee joint 7.5%, 17.5%, 25%, 32.5% and 17.5% of cases were found with grade 0, grade 1, grade 2, grade 3 and grade 4 OA knee, respectively. On right side, the mean difference in stride time, single support phase, step length, cadence and knee flexion extension were the parameters found to be significantly different with respect grades of osteoarthritis knee. On left side, the mean difference in single support phase, double support phase, mean velocity, stride length and step length were the parameters found to be different with respect grades of osteoarthritis knee. Parameters like stride time, single and double support phase of left side, mean velocity, cadence, hip flexion extension on right side, gait profile core of right and gait deviation index of left side were the parameters which were found to be significantly different among male and female participants.

Conclusion: 3D gait analyser can be used in routine for all cases of osteoarthritis not only to assess their gait abnormalities but also to assess the severity of osteoarthritis knee.

Key words: osteoarthritis knee, 3D gait analyser, severity of osteoarthritis, Kellgren Lawrence scale

ABBREVIATIONS

3D	-	3 Dimensional
AAOS	–	American Academy of Orthopaedic Surgeons
ACP	–	Autologous Concentrated Plasma
ASIS	-	Anterior Superior Iliac Spine
CPGS	-	Chronic Pain Grade Scale
GNP	–	Gross National Product
ICOAP	-	Intermittent and Constant Osteoarthritis Pain
KAHER	-	KLE academy of higher Education and Research
KCF	-	Knee Contact Force
KL	–	Kellgren–Lawrence
KOOS	-	Knee Injury And Osteoarthritis Outcome Score
MPQ	-	McGill Pain Questionnaire
NSAIDs	–	Non-Steroidal Anti-Inflammatory Drugs
NRS	-	Numeric Rating Scale
OA	-	Osteoarthritis
OARSI	-	Osteoarthritis Research Society International
PRP	-	Platelet-Rich Plasma
SF-MPQ	-	Short-Form McGill Pain Questionnaire
SF-36 BPS	-	Short Form-36 Bodily Pain Scale
VAS	-	Visual Analogue Scale

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INTRODUCTION

Osteoarthritis (OA) is the most common degenerative disorder usually pronounced as gradual destruction of cartilage, affecting multiple joints especially the weight-bearing joints like the hip joints and knee joints. The reduction in the functional ability which occurs due to the osteoarthritis has a notable impact on their quality of life[1].

Global burden of disease study reported that about 250 million population throughout the world, suffer from osteoarthritis and in United States, roughly about 1-2% of the gross national product (GNP) is spent on the prevention and treatment of osteoarthritis[2,3]. Due to the increase in the aging population, the proportion of cases with osteoarthritis of knee joint is steadily increasing and also in future, the same is expected to increase[4].

Due to this increasing burden of disease and noticeable reduction in the quality of life among the cases with osteoarthritis knee, there is a significant attention paid on the assessment of biomechanical processes in daily routine activities of them, especially the focus is on the stability of the knee joint[5,6].

Stability of the knee joint refers to the ability of the knee joint to maintain a particular position or to control the movement under varying external loads. As per the literature, stability is very well assisted by the neuromuscular system including the muscles which are attached to the joint and proprioception and by passive restraint provided by the capsules and ligaments of the joints[7,8].

Cases with osteoarthritis knee present with a widely varying symptoms, risk factors and clinical signs which results in more difficulties to classify the disease. Several studies classified the cases with osteoarthritis based on the radiographic findings alone[9,10]. But the association between the disease severity and presenting

complaints were very minimal[11,12]. In practice, a combined approach using the history and the radiographic findings were widely used.

However, due to the progression of osteoarthritis knee, the gait performance also widely varies and for the evaluation of the same a comprehensive assessment of gait function would help to exactly identify the prognosis and treatment modalities. Recently the modern 3 dimensional (3D) gait analysis is widely used for the assessment of gait among cases with OA knee and also it is found to be an effective tool which provides better biomechanical information about each joint. Also it provides several temporal waveforms for individual joints of the lower limbs. But due to the huge volume of data and its complexity its use in the clinical application has become quite difficult[13].

Several studies were conducted among the cases with osteoarthritis knee during walking and the gait assessment was done using gait analysis tools[14-17]. It was reported that varus alignment were commonly associated with osteoarthritis knee which signifies the importance of assessment of the frontal planes[18,19]. Greater knee abductor moments are found to be increasing with the increasing severity of osteoarthritis knee[9]. Knee moments and angles can be best describes using the sagittal plane[14,20] and decreased flexion angle, decreased flexor and increased internal rotator moments were found to be significantly associated with the severity of osteoarthritis of knee[14].

Due to the morphology of knee joint, it cannot function indigenously, more noticeably during the weight bearing activities which in turn affects the adjacent joints. Thus the impact of osteoarthritis of knee can be well appreciated in the adjacent joints like hip joints and ankle joints[21-23].

Though, the variability in the gait among the cases with osteoarthritis of knee was already assessed by several researchers, there are variations which occur with respect to age of the population and their ethnicity. Thus this study was performed to determine the differences in the gait parameters among cases with history and varying grades of knee osteoarthritis using 3d gait analyzer.

OBJECTIVE

Primary objective

- To determine the differences in the gait parameters among the cases with varying grades of knee osteoarthritis using 3d gait analyzer

Secondary objective

- To compare the alterations in the gait parameters between among the male and female cases

REVIEW OF LITERATURE

Anatomy of Knee Joint

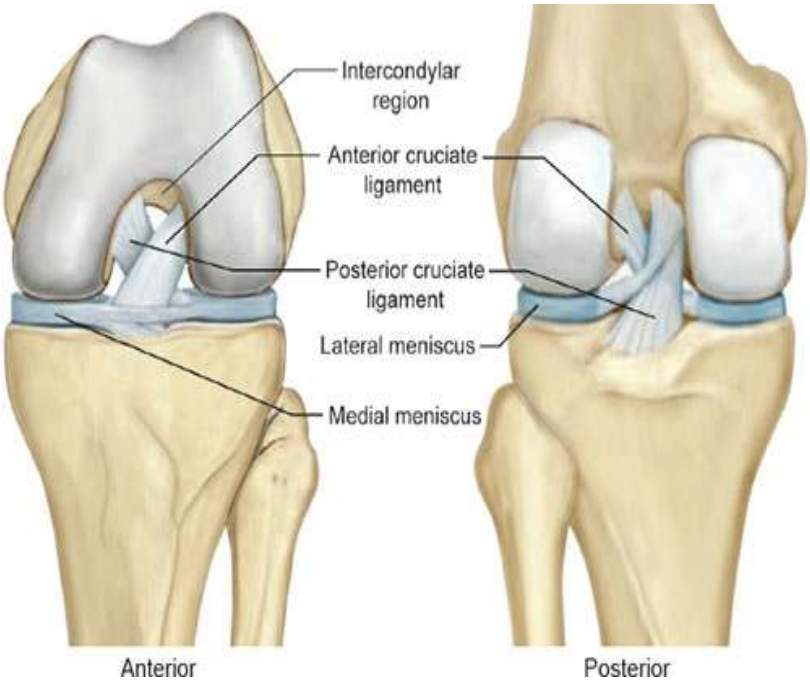


Figure 1: Anatomy of knee joint – Anterior, Posterior view

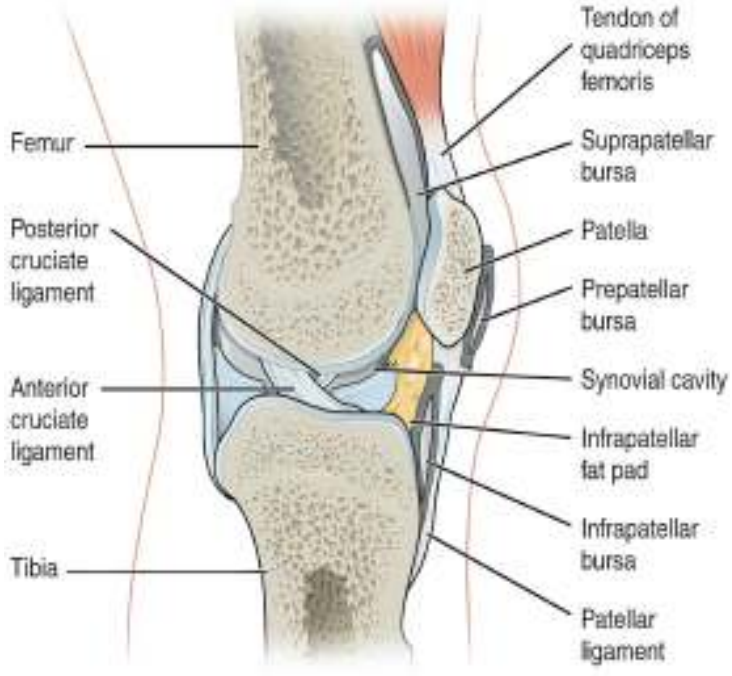


Figure 2: Anatomy of knee joint –Lateral view

Blood supply of knee joint

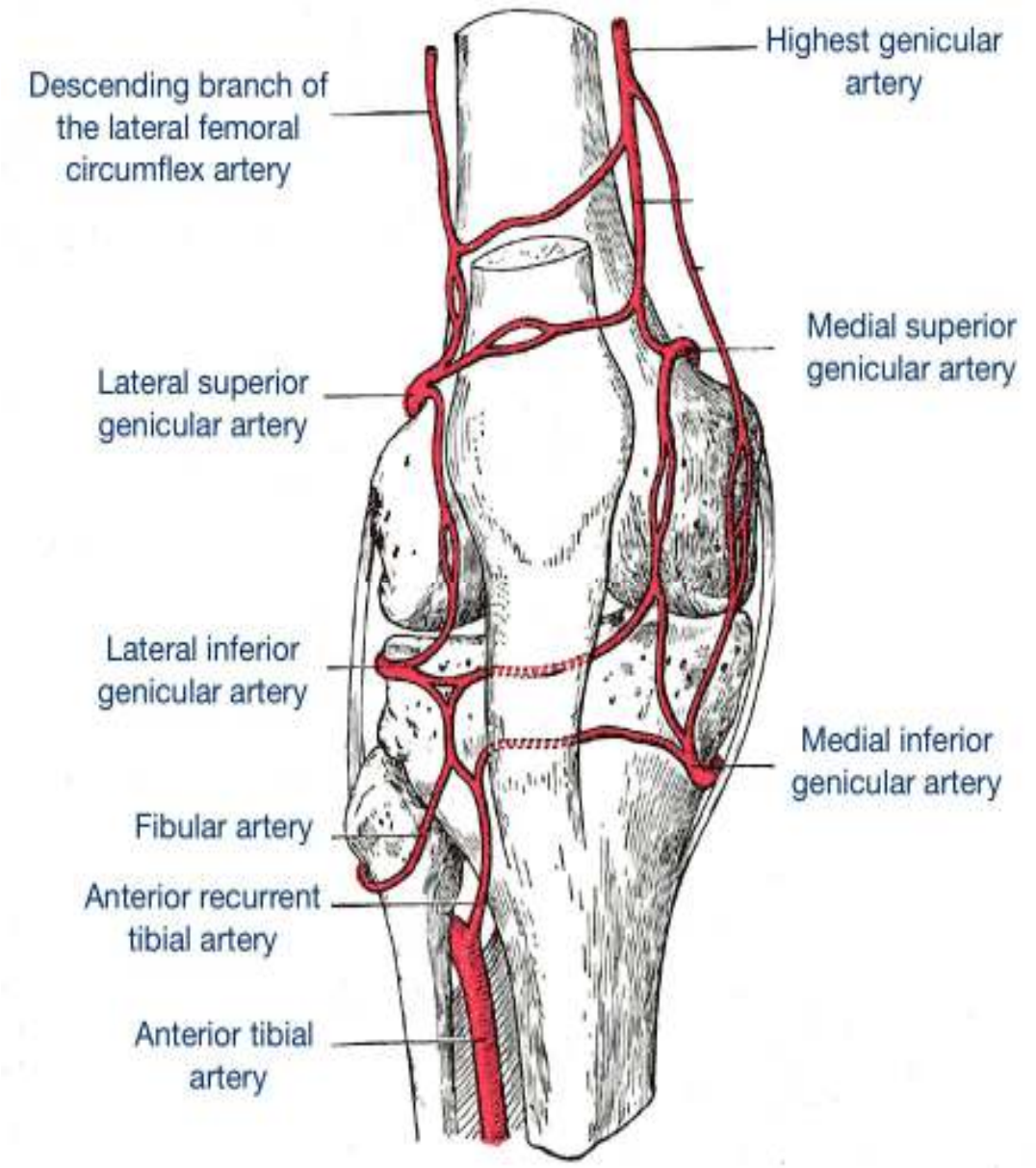


Figure 3: Blood supply of knee joint

Osteoarthritis knee

Osteoarthritis of knee joint is one of the commonly reported degenerative rheumatological disorders which affect the larger joint. In general the prevalence of osteoarthritis knee is reported between 19.2 - 27.8 %, which varies with respect to the age of the population[24]. The most frequently reported and symptoms which are commonly associated with the presence of osteoarthritis include pain in the joints and stiffness of the joints. Reduction in the knee joint excursion and manipulated force of ground reaction on those degenerative knee joints, affects functionality of the lower extremity which in turn affects the gait and results in abnormal mechanical alignment of the knee joint[25-27].

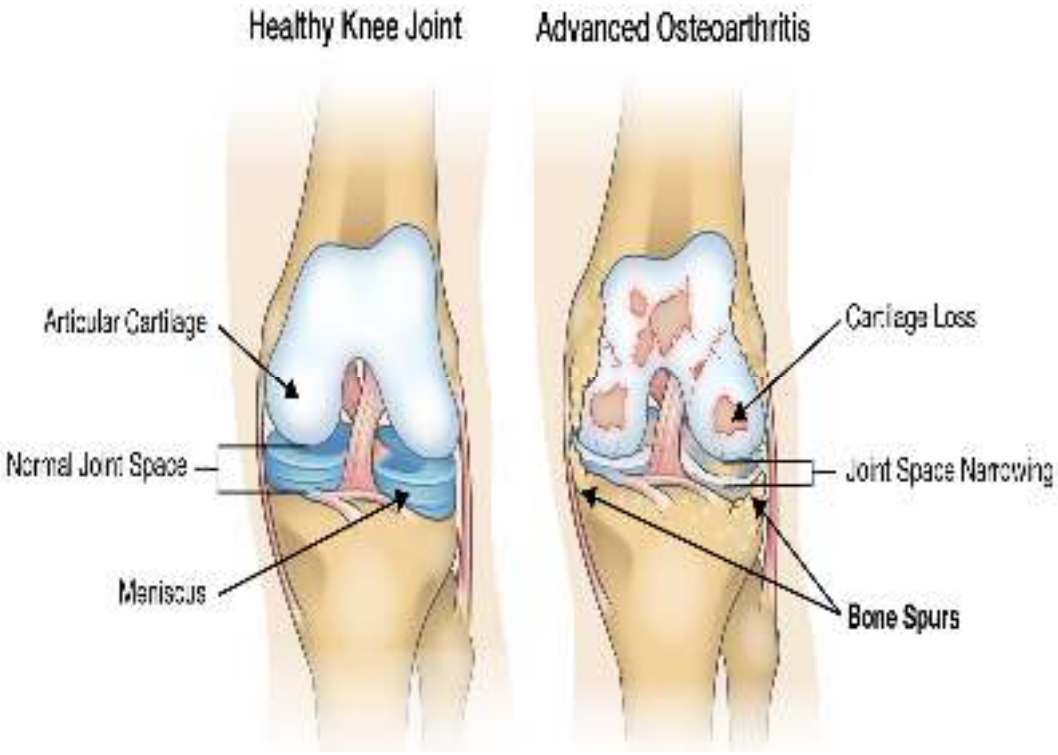


Figure 4: Osteoarthritis of knee joint

Risk factors of knee osteoarthritis[28]

Risk Factor	Comments
Age	Increased incidence with advancing age
Female gender	Increase in OA around menopause
Race/Ethnicity	Dependent on joint involved
Genetics	Genetic predisposition evident
Diet	Conflicting data—no consensus
Obesity	OA of the knee linked to increased weight
Injury/Surgery	Prior injury increases OA risk
Occupation	Repetitive use of joints increases risk
Physical activity/Sports	Conflicting data—no consensus

Mechanism of osteoarthritis knee

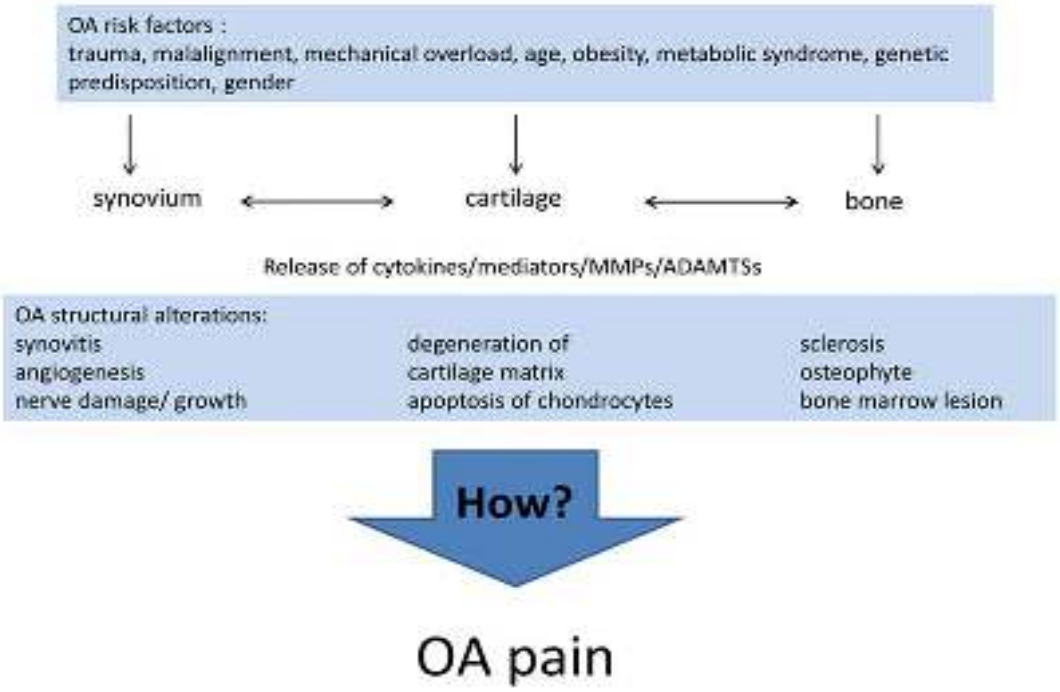


Figure 5: Mechanism of Osteoarthritis knee[29]

Structure of Healthy articular cartilage of knee Joint

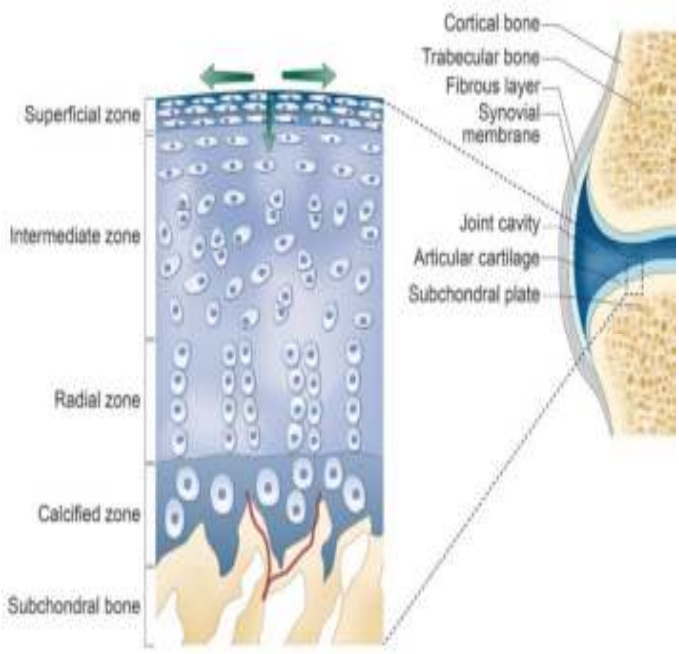


Figure 6: Structure of Healthy articular cartilage of knee Joint[30]

Structure and mechanism of articular cartilage with Knee Osteoarthritis

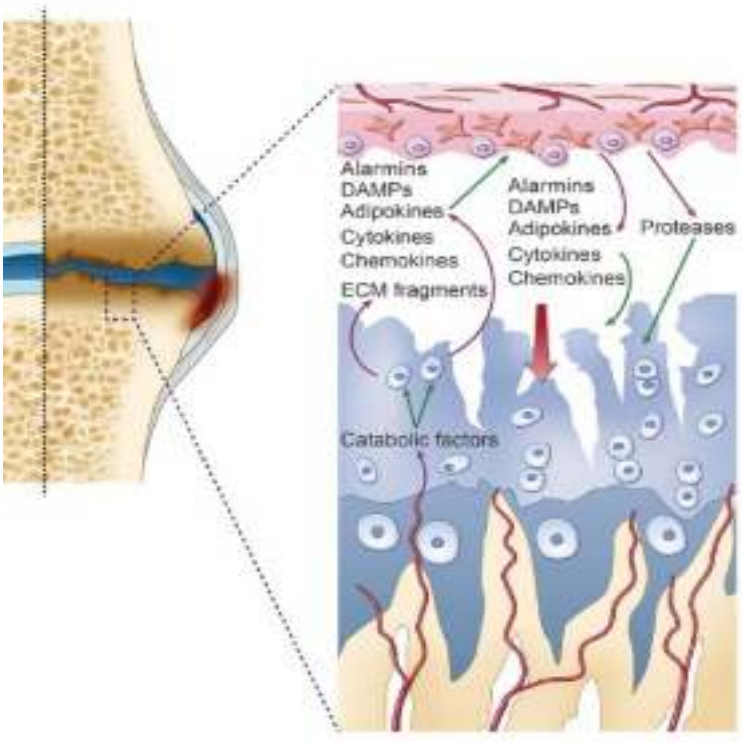
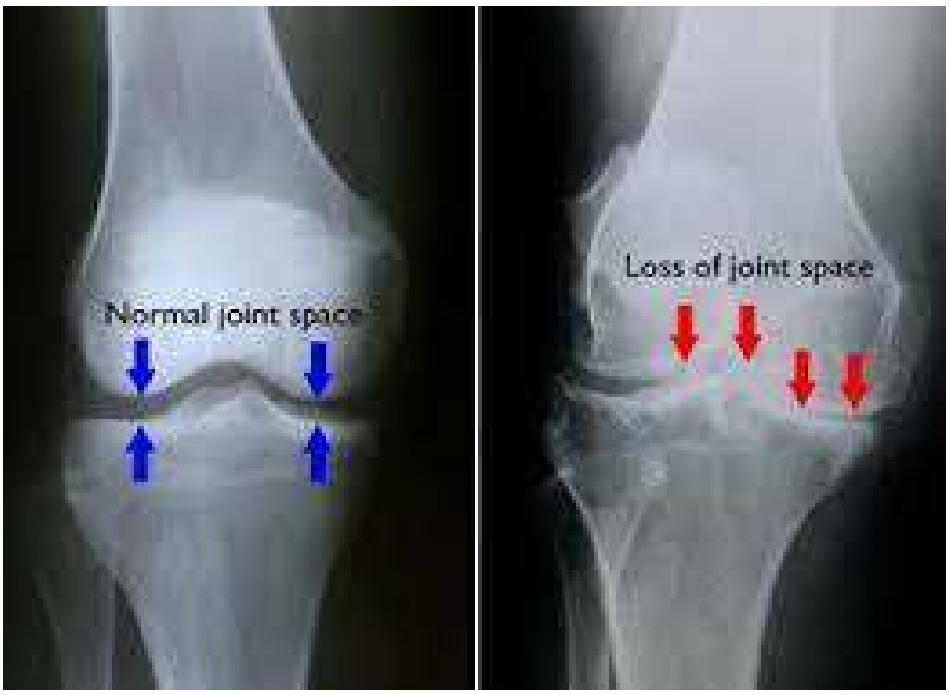


Figure 7: Structure and mechanism of articular cartilage with Knee Osteoarthritis[30]

Diagnosis of Osteoarthritis knee



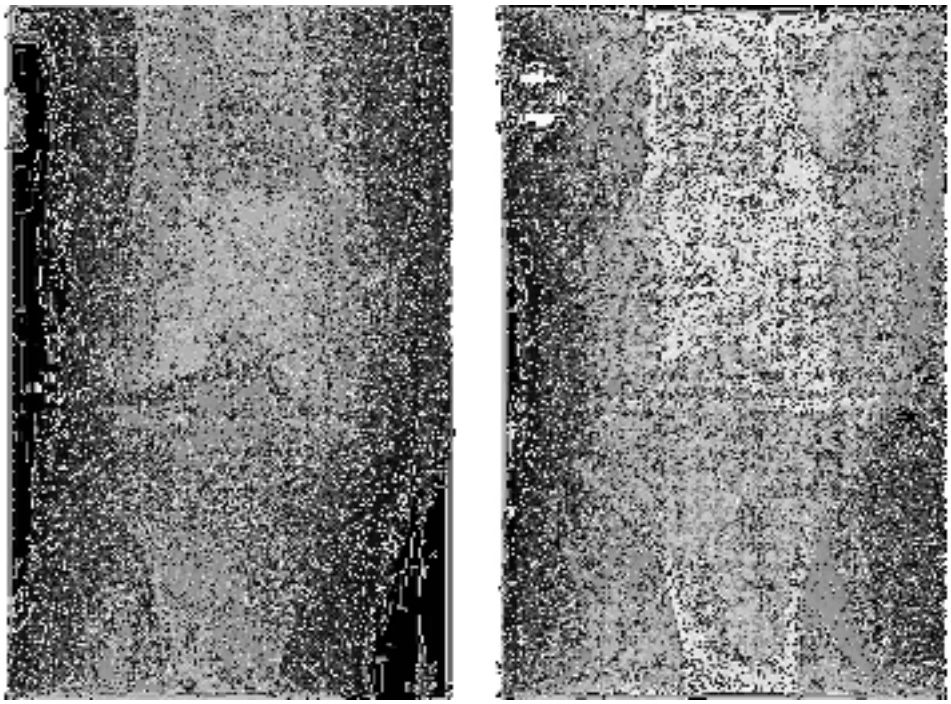


Figure 8: X ray Knee showing features of Osteoarthritis

Classification of osteoarthritis knee based on Kellgren–Lawrence (KL) scale[31]

Grade	Radiologic Findings
0	No radiological findings of osteoarthritis
I	Doubtful narrowing of joint space and possible osteophytic lipping
II	Definite osteophytes and possible narrowing of joint space
III	Moderate multiple osteophyte, definite narrowing of joint space, small pseudocystic areas with sclerotic walls and possible deformity of bone contour
IV	Large osteophytes, marked narrowing of joint space, severe sclerosis and definite deformity of bone contour

Radiological images of Kellgren–Lawrence (KL) scale

Figure 9: Radiographic images of Kellgren–Lawrence (KL) scale. KL

Treatment of knee Osteoarthritis

- Non operative management
  - Pharmacological management
  - Non pharmacological management
- Surgical management

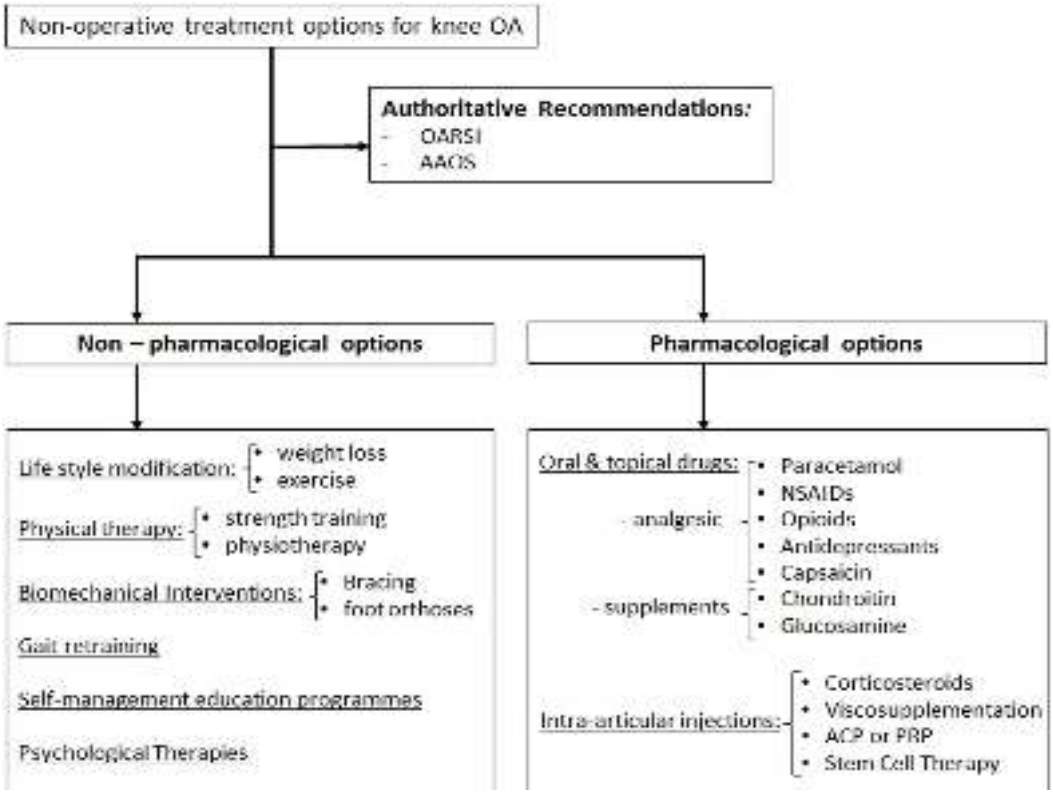


Figure 10: Non Surgical treatment options for knee osteoarthritis[32]

AAOS, american academy of orthopedic surgeons; ACP, autologous concentrated plasma; OARSI, osteoarthritis research society international; NSAIDs, non-steroidal anti-inflammatory drugs; PRP,platelet-rich plasma.

Surgical management options for knee osteoarthritis

Surgical management options are recommended only for those who were not responding with the non surgical treatment (pharmacological and non pharmacological treatment options). The common types of surgical options includes,

- Arthroscopic debridement
- Osteotomies
- Total knee arthroplasty

The ideal cases for each of these procedures are mentioned below[33].

Type of Surgery	Ideal Candidate for Surgery
Arthroscopic Debridement	• Normally aligned knee • Mild osteoarthritis • Displaced meniscus tear • Mechanical symptoms such as locking • Increasing pain • No bone marrow lesions
Osteotomies	• Younger patients (<60 years old) • <12 degrees of tibial or femoral angular deformity • Minimal arthritis in other two compartments • Ligament stability • Preoperative range of motion >90°
Total Knee Arthroplasty	• Older patients (>70 years old) • Moderate to severe osteoarthritis • Failed nonoperative treatment

3 D Gait analysis

Gait analyses is a modern and very effective tool in the analysis of biomechanical parameters of lower joints and it provides a superficial functionality view of all the joints of lower limb and more importantly it provides gait information like cadence, stride length and step width. As the degenerative disease progress, the gait functionality also varies accordingly which shows the strong association between the severity of disease and radiological grading of disease[34-36].

Though the modern gait analysis is an effective tool to examine all gait parameters however, it is important to assess its psychometric properties. Variability in the 3 dimensional (3D) gait analyses could be because of

- Intrinsic variations and
- Extrinsic variations

Intrinsic variations are the differences noted between intra-individuals that usually occur naturally, either through trial-to-trial or subject-to-subject variability[36].

Extrinsic variations refer to the errors that occurs during the measurement and that occurs because of positioning of the reflective markers[35].

In order to reduce this bias, the best option suggested is that collection of data from different trials of walking. It was reported that in healthy subjects, five trials are sufficient to get the better results[37,38].

Recent Literatures:

Zahrani KS et al[39] (2002) conducted a study among the cases with severe osteoarthritis knee and reported that the cases with severe osteoarthritis knee was found to have a lower walking speed, reduced stride length and a lengthen stance when compared with the non osteoarthritis knee controls. These differences in the gait parameters among the cases with severe osteoarthritis knee and healthy non osteoarthritis knee controls were found to be statistically significant, in their study. Also the cases with severe osteoarthritis knee was found to have reduced movements at all major joints of lower limb and reduced powers in ankle when compared with the non osteoarthritis knee controls. These differences in the gait parameters among the cases with severe osteoarthritis knee and healthy non osteoarthritis knee controls were found to be statistically significant, in their study. The only parameter which was found to be non significant in their study was degree of ankle plantar flexion instance, in their study. They concluded that the gait abnormalities were due to instability of the knee joint in stance.

Weidow J et al[40] (2006) performed a study and reported that at midstance, cases with lateral osteoarthritis was found to have increased adduction of the hip joint. The femur position at maximum external rotation was found to be statistically similar in lateral osteoarthritis, medial osteoarthritis and also among the controls without any osteoarthritis knee, in their study. Among the patients with medial osteoarthritis, less external tibial rotation was noted and it was found to be statistically significant when compared with the non osteoarthritis knee subjects, in their study. They also stated that they noted a significant link between OA knee and hip joint's biomechanics.

Lewek MD et al[41] (2006) conducted a study among cases with medial knee osteoarthritis and reported that the cases were noted with side frontal plane variability

however the difference was found to be statistically insignificant when compared with the non osteoarthritis knee controls, in their study. On assessing the associated parameters, they reported that laxity and medial co-contraction were the factors which influence the amount of joint motion variability in the affected knee of the cases with osteoarthritis. Also they stated that pain was not found to influence the gait variability, in their study.

Lynn SK et al[42] (2007) performed a study and reported that the cases with medial and lateral osteoarthritis implies that the extreme gait profiles noted in these group of cases is considered important in order to explain the cartilage breakdown and the development of osteoarthritis, in their study.

Astephen JL et al[43] (2007) performed a study and reported that the gait parameters were noted among the cases with osteoarthritis knee compared to the subjects without osteoarthritis knee. These differences in the gait parameters among the cases with osteoarthritis knee and healthy non osteoarthritis knee controls were found to be statistically significant, in their study. Also the cases with severe osteoarthritis knee were found to be reported with several momental abnormalities in the joints of lower limb and they stated that the gait parameters worsen with the severity of osteoarthritis knee, in their study.

Esch VD et al[44] (2008) conducted a study among sixty cases with osteoarthritis knee to assess the stability of the knee using varusevalgus motion. They reported that there were no relationships noted with between varusevalgus motion and muscle strength, joint laxity, proprioception, and skeletal alignment. Thus they concluded that the

varusevalgus motion cannot be considered as a tool to assess the knee joint stability, in their study.

Lynn SK et al[45] (2008) in their study reported that in their study they found a high late stance in the adduction moment of knee among the cases with osteoarthritis knee compared to the normal healthy controls, in their study.

Huang SC et al[46] (2008) performed a study stated that that rather providing training of the knee muscles alone, a combined approach with training of the both knee and hip muscles along with pelvic control should be provided in order to have better rehabilitation.

Heiden T et al[47] (2009) conducted a study and reported that cases with osteoarthritis had reported more pain and symptoms on assessing them using a questionnaire. Also they noted greater lateral muscle activation among the cases with osteoarthritis which were significantly associated with the magnitude of their adduction moments.

Zeni JA et al[48] (2009) performed a study and reported that cases with osteoarthritis knee were found to have lower knee and ankle joint moments, and knee excursion while walking when compared to the non osteoarthritis knee controls.

These differences in the gait parameters among the cases with osteoarthritis knee and healthy non osteoarthritis knee controls were found to be statistically significant, in their study. They reported that except knee excursion, all the other gait parameters were significantly different in the cases those who has osteoarthritis knee when compared with non osteoarthritis knee controls.

Richards C et al[49] (2010) performed a study to assess the knee contact force (KCF) among the cases with different degrees of osteoarthritis severity. They reported that

cases with moderate osteoarthritis were found to have KCF which was similar to the healthy cases without osteoarthritis knee.

However cases with severe osteoarthritis were found to have initial peak KCF similar to healthy cases, later the pattern of the KCF was found to be varying. These differences in the KCF among the cases with severe osteoarthritis knee and healthy non osteoarthritis knee controls were found to be statistically significant, at the end, in their study.

Ornetti P et al[50] (2010) conducted a systematic review and reported that the cases with osteoarthritis knee was found to have decreased walking speed, stride length and knee flexion compared to the non osteoarthritis knee subjects.

Yakhdani HRF et al[51] (2010) in their study they reported that cases with osteoarthritis knee was found to have lower walking speed when compared to the non osteoarthritis knee controls. These differences in the gait speed among the cases with osteoarthritis knee and healthy non osteoarthritis knee controls were found to be statistically significant, in their study. The difference was found to be correlated to the number of episodes of fall.

Butler RJ et al[52] (2011) performed a study and reported that cases with lateral knee osteoarthritis was found to have lower knee adduction excursion and reduced peak knee abduction moment compared with the healthy non osteoarthritis knee controls. These differences in the gait parameters among the cases with lateral OA knee and healthy non osteoarthritis knee controls were found to be statistically significant, in their study.

They concluded that cases with lateral knee osteoarthritis were found to have frontal-plane gait mechanics at knee which was found to be significantly different from the cases with medial knee osteoarthritis. These differences in the frontal plane

gait mechanics among the cases with lateral OA knee and medial knee osteoarthritis were found to be statistically significant, in their study.

Kiss RM et al[53] (2011) performed a study and reported that among the cases with osteoarthritis knee, they found a reduced variability of angular parameters on the side of osteoarthritis knee which represents that there is a reduced joint flexibility. This in turn results in reduction in the movements of the legs, as noted along with high variability of ST parameters, in their study.

Also they reported that there was a significant reduction in flexibility of the joint which was found to be linked with the reduced complexity of movement, in their study. Apart from these findings, they also commented that in their study they found difference of gait parameters were linked with OA knee is dependent on the gender.

Gaudreault N et al[54] (2011) conducted a study among the osteoarthritis knee cases and assessed their gait parameters before and after the treatment with physiotherapy. They reported that they noted an increased quadriceps and hamstring strength following the physiotherapy treatment compared to the pre treatment status, in their study.

Also higher first peak flexion moment, reduced adduction moment impulse and smaller rotation angle range were noted after the treatment with physiotherapy, in their study. The mean differences in these parameters before and after the treatment with physiotherapy were found to be statistically significant.

Laroche et al[55] (2011) performed a study and reported that spatio - temporal parameters, kinematic joint and trunk angles are the most reliable parameters of 3dimensional gait analysis among the cases with hip osteoarthritis, in their study.

They reported that the mean differences in angles measured by 3D gait analysis and angles measured manually using a goniometer were reported to be more similar with a difference of less than one percentage.

Zeni JA et al[56] (2011) conducted a study and reported that an increase in ankle contribution and a reduction in hip's role while speed of walking was increased were noted among the cases with osteoarthritis knee however the same was not reported among the controls. These differences in the gait parameters among the cases with osteoarthritis knee and healthy non osteoarthritis knee controls were found to be statistically significant, in their study. Also reduction in the gait speed was noted among the cases with osteoarthritis knee along with joint pain and muscle weakness, significantly.

Baert IAC et al[57] (2013) performed a study among the cases with early osteoarthritis knee and reported that these cases were found to have unaltered gait and hamstring muscle strength compared to the known cases of osteoarthritis knee, in their study. However, the cases with early osteoarthritis knee were reported to have statistically significant quadriceps weakness compared with the known cases of osteoarthritis knee.

Turcot K et al[58] (2013) performed a study and reported that the cases with osteoarthritis knee were found to have significantly different gait patterns. Cases with varus knee were found to be significantly correlated with the trunk movements when compared with the cases with valgus knee, in their study. Also they stated that the valgus knee cases were found to have reduced pain and reduced functional deficits compared to the cases varus knee.

Sagawa JY et al[59] (2013) performed a study among the cases with osteoarthritis knee and reported that cases with varus were found to have high thorax obliquity on the

stance limb and also noted with reduced forward displacement however cases with valgus were reported only with decreased forward displacement, in their study.

Esrafilian A et al[60] (2013) performed a study and reported that the excursion of the knee, hip and pelvis in sagittal plane and mediolateral plane were higher among the osteoarthritis knee when compared with the non OA knee cases. These differences in the gait parameters among cases with osteoarthritis knee and healthy non osteoarthritis knee controls were found to be statistically significant, in their study.

Also they noted that the energy consumption was found to be more among the cases with osteoarthritis knee than the non osteoarthritis knee controls. These differences in the energy consumption among the cases with osteoarthritis knee and healthy non osteoarthritis knee controls were found to be statistically significant. But, the margin of stability was found to be lower among the cases with osteoarthritis knee compared to the non osteoarthritis knee controls. These differences in the margin of stability among the cases with osteoarthritis knee and healthy non osteoarthritis knee controls were found to be statistically significant.

Baudet A et al[61] (2014) in their study they reported that the difference in the kinematic profile for knee varus knee or valgus knee and knee flexion or knee extension was found to be lower and higher, respectively, in their study. These differences in the kinematic profile of gait parameters among the cases with varus knee or valgus knee and healthy non osteoarthritis knee controls were found to be statistically significant.

Bytyqi D et al[62] (2014) in their study reported that cases with osteoarthritis knee were found to have less extension at the stance and initial swing phase. These differences in

the gait parameters among the cases with osteoarthritis knee and healthy non osteoarthritis knee controls were found to be statistically significant, in their study. Also higher adduction angle was reported among the cases with osteoarthritis knee compared to the healthy non osteoarthritis knee controls and the difference was significant. In their study they stated that cases with osteoarthritis knee retained a neutral position at −0.4°however the non osteoarthritis knee healthy controls retained position at −2.2°, in their study. They concluded that the cases with osteoarthritis knee reported an altered screw-home mechanism by reduced excursion in axial tibial and sagittal rotation.

Tadano S et al[63] (2016) conducted a study and reported that the abduction in the ankle joints during stance were reduced in order to prevent knee adduction with increasing severity of OA knee..

Phinyomark A et al[64] (2016) performed a study and reported that female cases with osteoarthritis knee and non osteoarthritis knee females were found to have higher abduction of knee when compared with the male cases with osteoarthritis knee and non osteoarthritis knee. These differences in the gait parameters among the female cases with and without osteoarthritis knee and male cases with and without osteoarthritis knee were found to be statistically significant, in their study. Also no differences were reported with any of the discrete gait kinematic parameters between the cases with and without osteoarthritis knee either among the male and female study population.

Kwon SB et al[65] (2019) performed a study and reported that the variables like moments like knee extension, abduction and rotational, hip abduction and extension and ankle dorsiflexion, angles like knee flexion, hip extension, cadence and stride

length were found to better pronounce the severity of knee osteoarthritis using KL system of classification, in their study.

Sparkes V et al[66] (2019) performed a study and reported that cases with osteoarthritis was found to have low peak frontal hip and reduced anterior ground reaction force compared to the non osteoarthritis knee controls. These differences in the gait parameters among the cases with osteoarthritis knee and healthy non osteoarthritis knee controls were found to be statistically significant, in their study.

Also they stated that the osteoarthritis cases had slower walking cadence and they took longer on timed functional measures, in their study. These differences in the gait cadence and time taken for functional measures among the cases with osteoarthritis knee and healthy non osteoarthritis knee controls were found to be statistically significant.

Pacifico D et al[67] (2020) performed a study among cases with unilateral osteoarthritis knee and reported that they found a statistically significant side differences for single-limb support duration and also for the ground reaction force at touchdown. These differences in the gait parameters among the cases with unilateral osteoarthritis knee and healthy non osteoarthritis knee controls were found to be statistically significant.

Ismailidis P et al[68] (2020) conducted a study to assess the effect of speed of walking on kinematic variables among the cases with osteoarthritis knee and reported that at patient's own walking speed, lower knee flexion was noted among the cases with osteoarthritis knee during stance and also during swing.

Also greater ankle dorsiflexion was noted during stance phase and lesser hip extension at the end of stance was reported among the cases with osteoarthritis knee

compared to the non osteoarthritis knee healthy controls, in their study. These differences in the gait parameters among the cases with osteoarthritis knee and healthy non osteoarthritis knee controls were found to be statistically significant.

The differences in sagittal plane gait kinematics parameters among cases with osteoarthritis knee were mainly reduced the respect to the walking speed of the cases, in their study.

Kwon SB et al[69] (2020) performed a study and reported that the 3 dimensional gait analyses along with radiological classification of grading the osteoarthritis knee using KL grading system is the best to diagnose the knee osteoarthritis with better accuracy in diagnosis, in their study.

Pinto RF et al[70] (2020) conducted a study and reported that the parameters like frontal and sagittal plane knee angles and moments among the cases with osteoarthritis knee evaluated using a treadmill-based gait analysis system were found as the better and more efficacious markers to assess the gait among the cases with osteoarthritis knee, in their study.

Schrijvers JC et al[71] (2021) conducted a study and reported that there are differences between the findings of the different gait laboratories which could obstruct the exact comparison of gait database among the cases with knee osteoarthritis, in their study. In order to reduce these differences, they suggested harmonization of gait analysis, in the very first step itself.

Ismailidis P et al[72] (2021) conducted a study and reported that the cases with knee osteoarthritis were found to have reduced walking speed, increased stride duration, lessen stride length and reduced cadence compared to the cases without osteoarthritis knee. These differences in the gait parameters among the cases with osteoarthritis

knee and healthy non osteoarthritis knee controls were found to be statistically significant. Peak knee flexion at stance and swing was found to be reduced in the side which was affected with osteoarthritis compared to the unaffected non osteoarthritis side, in their study. Also the dissimilarity in the flexion of knee at stance on osteoarthritis knee side and healthy non osteoarthritis knee controls were found to be statistically significant, in their study. Also notably knee range of motion during loading response and swing was found to be reduced in the non osteoarthritis knee.

MATERIALS AND METHODS

Study Design:

A cross sectional study, to determine the differences in the gait parameters among the cases with varying grades of knee osteoarthritis using 3D gait analyzer.

Study Area:

Department of Orthopedics in KLE academy of higher Education and Research (KAHER), Jawaharlal Nehru Medical College, Belagavi

Study population:

Cases with osteoarthritis knee

Study period:

January 2020 to December 2020

Inclusion criteria:

- Cases aged 50 years and above
- Osteoarthritis of bilateral knee joints

Exclusion criteria:

Cases with

- Any gait pathologies
- Use of ambulatory aids
- Any knee surgeries
- Arthroplasty of hip and knee
- History of injury to the knee within previous six months
- Tumour, ligament, meniscal or cruciate abnormalities
- Rheumatoid arthritis
- Connective tissue disorder
- Intra-articular steroid medication in the past 2 months and
- Central or peripheral neuropathy

Sample size:

Based on the study conducted by Jayalath JLR et al[73] using single time support (m/s) standard deviation of 0.16 m/s with 95% confidence and 5% margin of error, the sample size was calculated to be 39 and thus it was rounded to 40.

$$n = \frac{Z^2\sigma^2}{e^2}$$

Where Z= 95% confidence (1.96), σ = Standard deviation (0.16), e = Margin of error (5%)

Hence a total of forty cases with OA knee joint were included.

Ethical committee approval:

Ethical committee approval was obtained for this study to determine the differences in the gait parameters among the cases with varying grades of knee osteoarthritis using 3D gait analyzer from the Institutional Human Ethics Committee. (Annexure I).

Data Collection:

The principal investigator used a pre-structured proforma to assess all study participants for their demographic and clinical presentation after receiving written informed consent. Following that, the principal investigator obtained the participants' detailed medical histories and conducted a clinical examination.

Also all the cases underwent bilateral knee X rays (both anterior and posterior views) and their entire gait parameters were assessed using 3D gait analyzer. The gait analysers used for the study was BTS SMART GAIT ANALYSER by following simple Halen Hayes protocol and 3D gait analysis was supervised by Dr. Anand Heggeannavar, M.P.T.

Procedure:

Lower limb motion was tracked using a motion capture system with one position sensor, equipped with embedded infrared cameras. The system tracked the position and orientation of clusters of active markers. In Simple Helen Hayes protocol, there are 6 phases.(Clinical Photographs Annexure iv).

Subject preparation:

Anthropometric measurements like ASIS breadth, pelvic depth, leg length, knee diameter, malleolus width, height and weight are marked) and markers are attached on different parts of body .In Simple Helen Hayes 15 markers are attached 1 on sacrum, 2 on Anterior Superior Iliac Spine (ASIS), 2 on thigh, 2 on knee, and 2 on calf, 2 on lateral malleoli, 2 on heel and 2 on second metatarsal head. This version is used just to evaluate lower limb and pelvis behavior.

Acquisition phase:

- Standing task
- Walking task

Elaboration phase:

- Tracking
- Calculation protocol selection
- Events

Reporting phase

- Mean spatio-temporal parameters
- Gait profile score
- Gait variable score
- Gait deviation index

Checking marker location

After doing gait analysis main parameter to be analyzed were

- Temporal parameters
  - Stride time (sec)
  - Stance time (sec)
  - Swing time (sec)
  - Single support phase (%)
  - Double support phase (%)
  - Mean velocity (m/s)
  - Mean velocity (%height):
  - Cadence (steps/min)
- Spatial parameters
  - Stride length (m)
  - Step length (m)
  - Step width (m)
- Kinematic parameters
  - Hip Flexion - Extension (degree)
  - Knee Flexion - Extension (degree)
  - Knee Valgus - Varus (degree)
  - Knee rotation (degree)
- Kinetic parameters
  - Knee Movement (N*m/kg)
  - Knee power (Wt/kg)
- Ground Reaction Force
  - Vertical Force (% body weight)

Also physical function was evaluated with SF 36 Short Form Health Survey Questionnaire[74] and pain intensity will be described using Visual Analogue Scale (VAS) where the current pain intensity is noted from the respondents and the

respondent is asked to make a point at the VAS scale representing their intensity. Using a ruler, the score is determined by measuring the distance (in mm) on the 10cm line and the following cut-off points was considered[75].

Severity of Pain	**Scale**
No pain	0-4 mm
Mild pain	5-44 mm
Moderate pain	45-74 mm
Severe pain	75-100 mm

Data analysis

SPSS was used to analyse the data (Version 19). For quantitative variables, descriptive statistics such as mean, standard deviation, and proportions (percent) were calculated. Mann-Whitney U test and Chi Square test were used to test the hypothesis. Statistical significance was defined as a p value of less than 0.05.

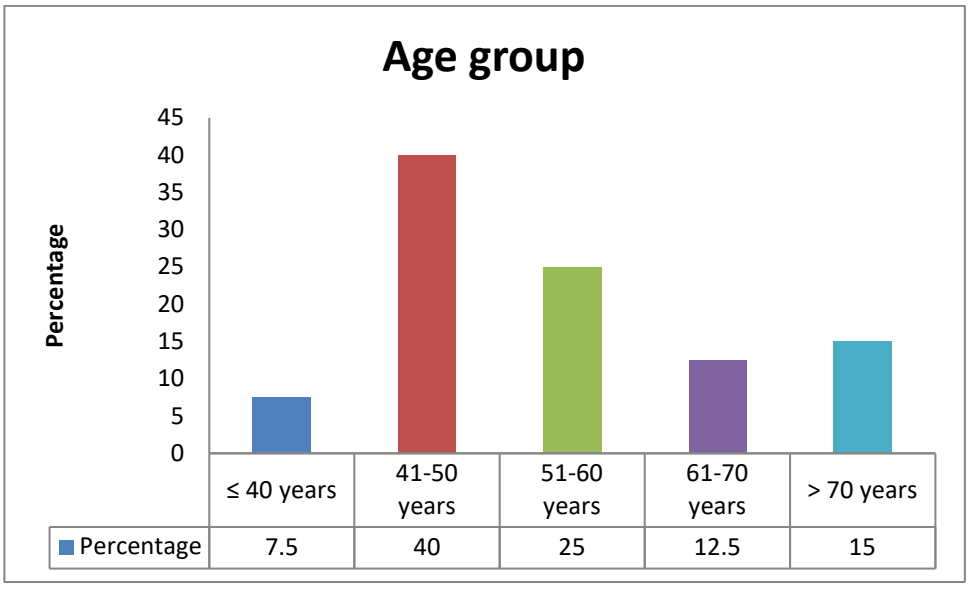
RESULTS

In this study to analyze the differences in Gait among knee osteoarthritis patients there were 7.5% of the participants were less than 40 years of age, 40% of the participants were in the age group of 41 -50 years while 25% of the participants were between 51 – 60 years. In the age group of 61 -70 years and above 70 years of age 12.5% and 15% of the participants were present in this study.

Table 1: Proportion of participants based on age group

Age group	Frequency	Percentage
≤ 40 years	3	7.5
41-50 years	16	40.0
51-60 years	10	25.0
61-70 years	5	12.5
> 70 years	6	15.0
Total	40	100.0

Graph 1: Proportion of participants based on age group

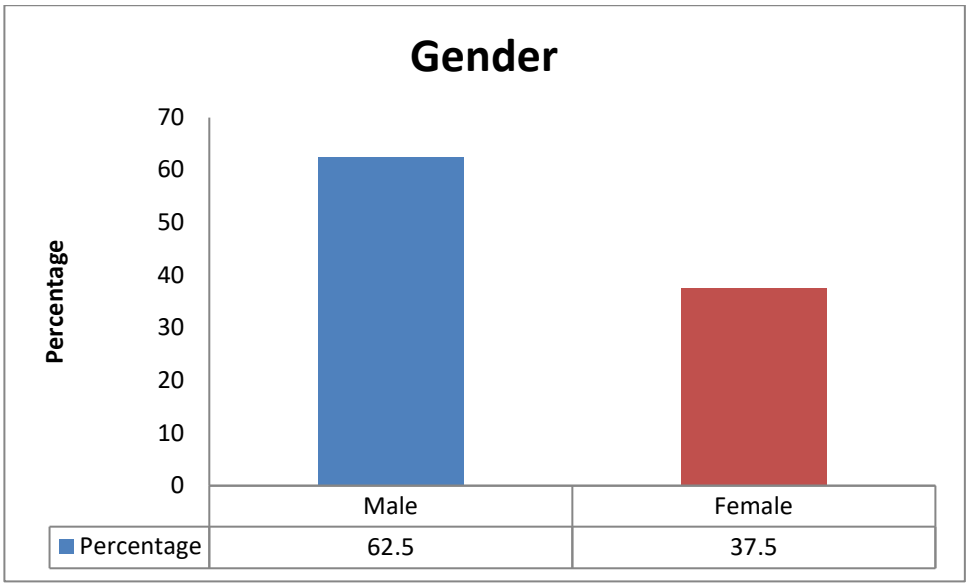


Among all the participants 62.5% of them were male participants and 37.5% of them were female participants, in this study male participants with osteoarthritis were found to be higher.

Table 2: Gender wise distribution of study participants

Gender	Frequency	Percentage
Male	25	62.5
Female	15	37.5
Total	40	100.0

Graph 2: Gender wise distribution of study participants

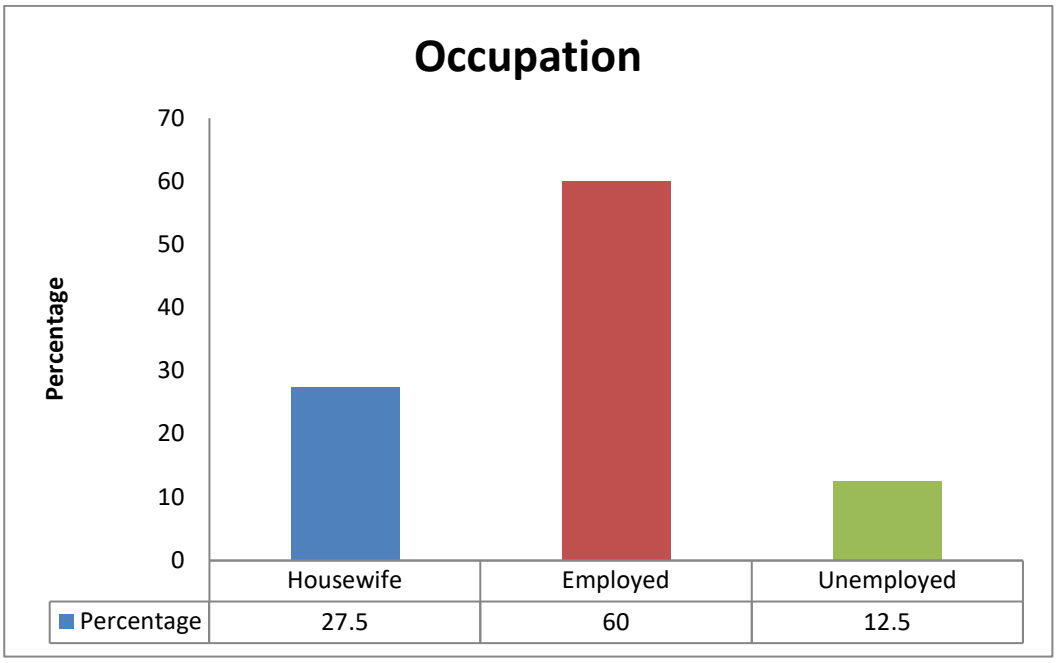


In this current study 27.5% of the participants were housewives, 60% of them were employed, and 12.5% of the participants are unemployed.

Table 3: Proportion of participants based on Occupational status

Occupation	Frequency	Percentage
Housewife	11	27.5
Employed	24	60.0
Unemployed	5	12.5
Total	40	100.0

Graph 3: Proportion of participants based on Occupational status

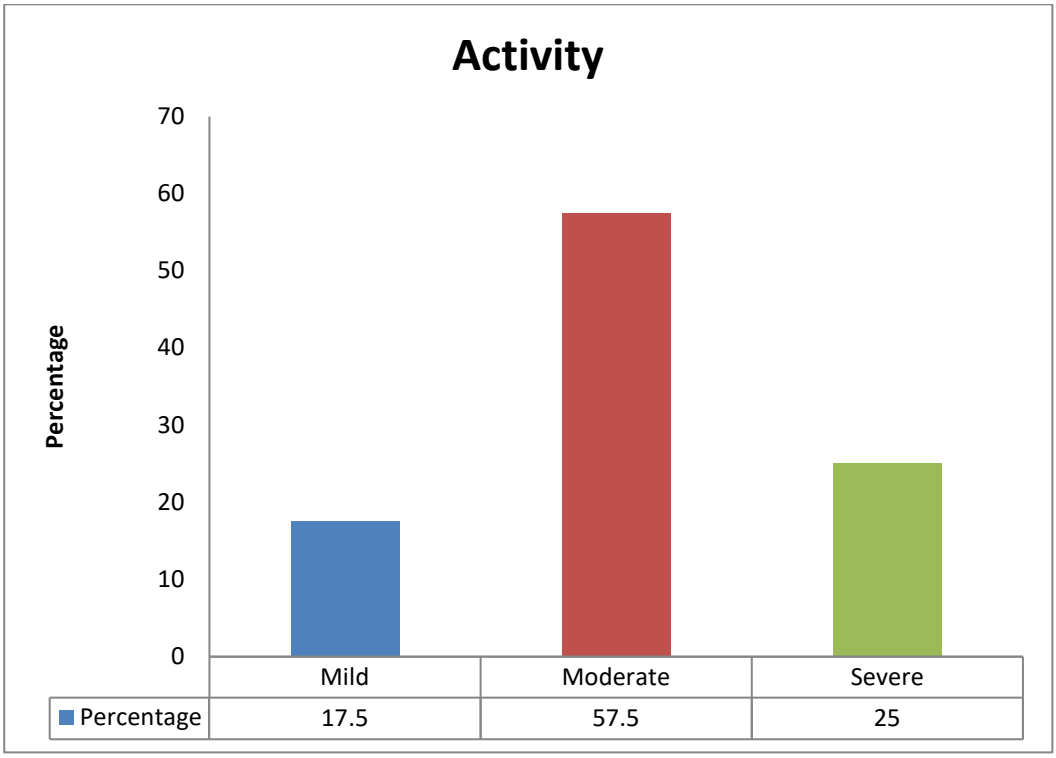


Based on the activity status maximum of 57.5% of the participants had moderate activity while 25% of the participants had severe activity while 17.5% of the participants had mild activity of work.

Table 4: Activity status of the study participants

Activity	Frequency	Percentage
Mild	07	17.5
Moderate	23	57.5
Severe	10	25.0
Total	40	100.0

Graph 4: Activity status of the study participants

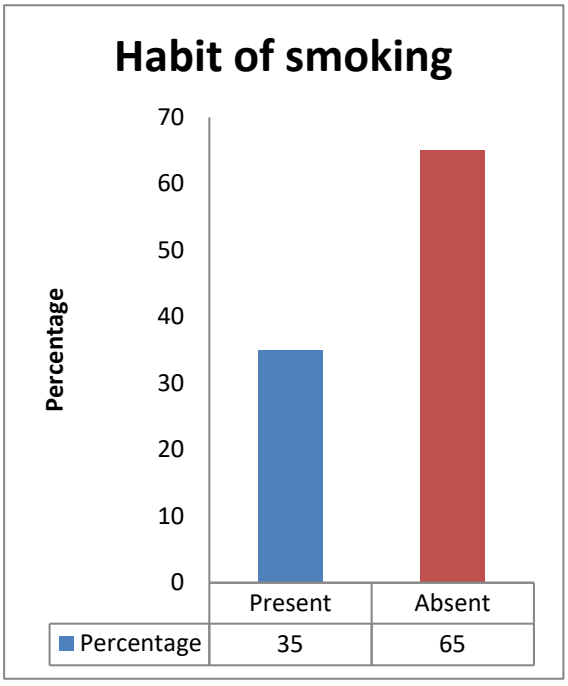


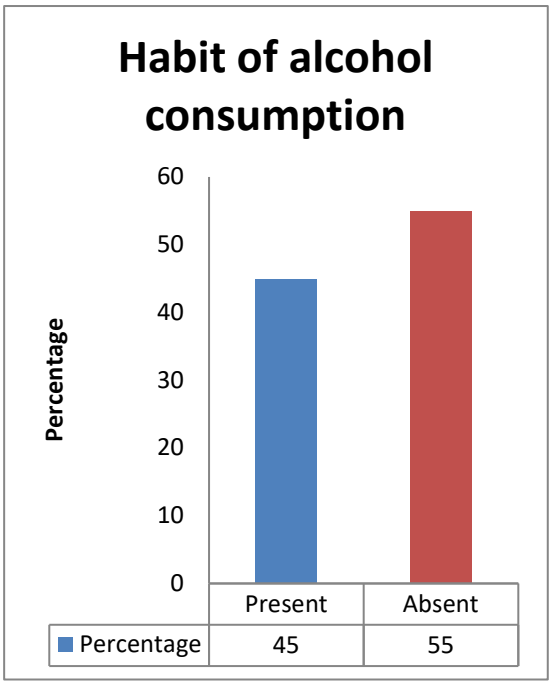
Habit of smoking was found among 35% of the patients whereas 65% of the patients were non- smokers. Alcohol consumption was found among 45% of the cases.

Table 5: Proportion of participants based on habit of smoking and Alcohol consumption

Variables	Frequency	Percentage
Habit of smoking		
Present	14	35.0
Absent	26	65.0
Habit of alcohol consumption		
Present	18	45.0
Absent	22	55.0
Total	40	100.0

Graph 5: Proportion of participants based on habit of smoking and Alcohol consumption



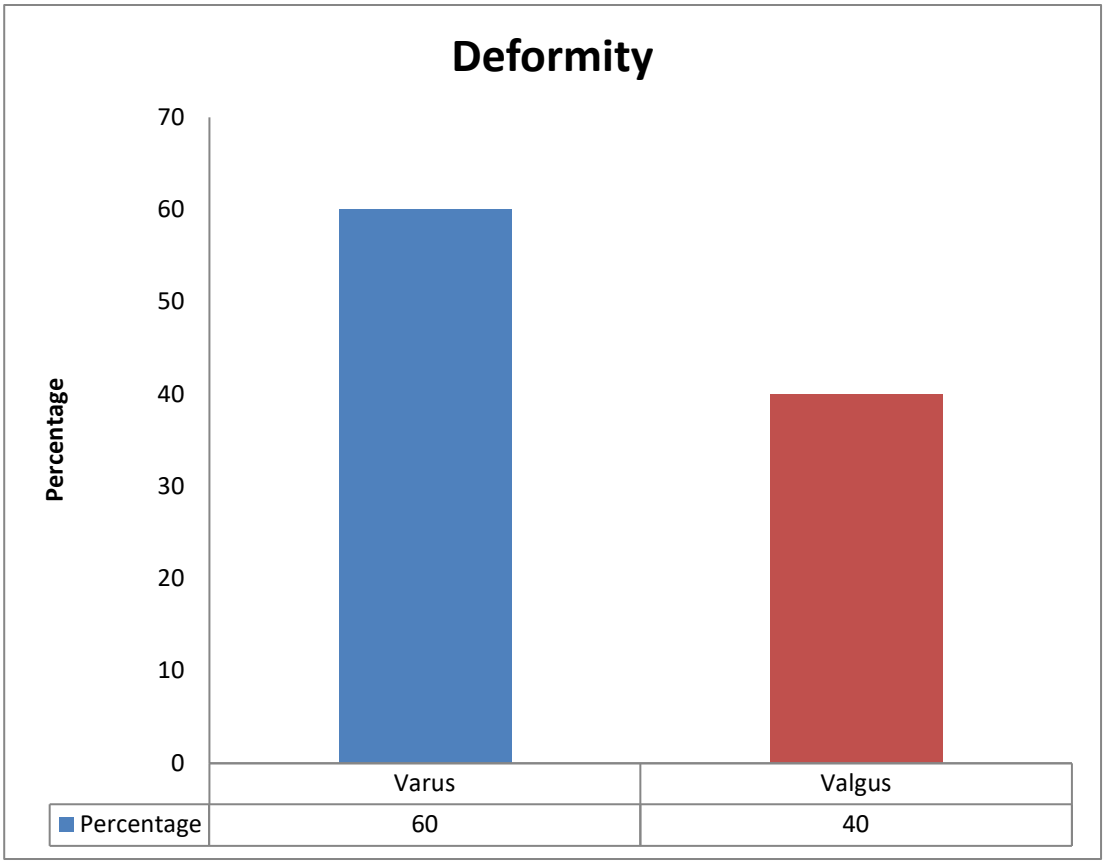


In this current study varus deformity was the common one found among 60% of the participants and valgus deformity was seen among 40% of the participants.

Table 6: Deformity among the study participants

Deformity	Frequency	Percentage
Varus	24	60.0
Valgus	16	40.0
Total	40	100.0

Graph 6: Deformity among the study participants

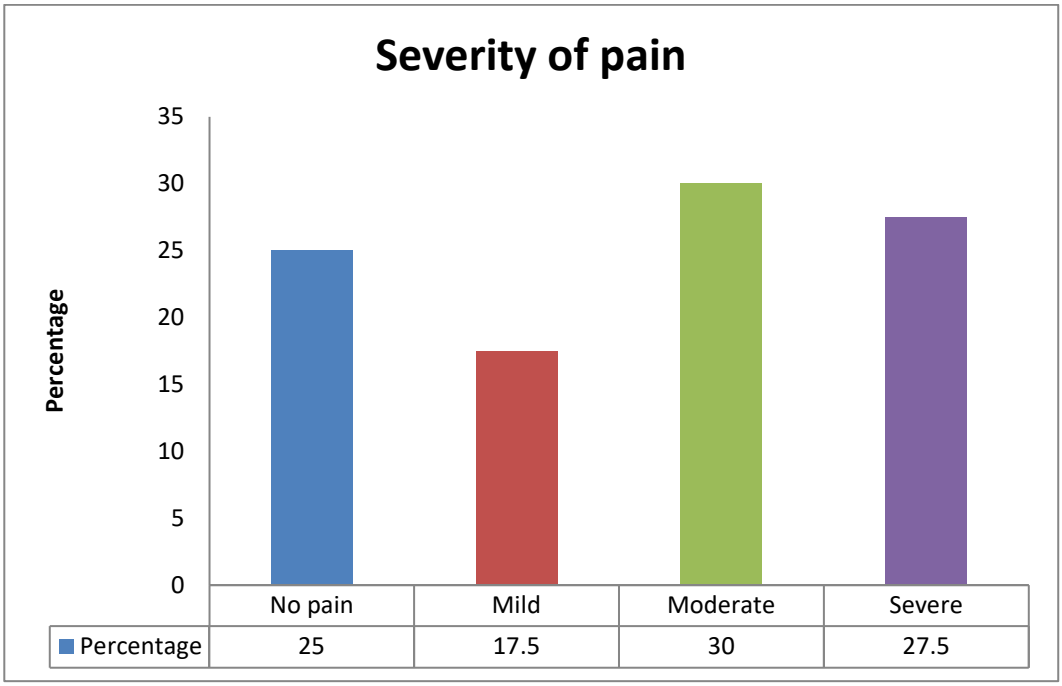


On assessing the severity of pain 17.5%, 30% and 27.5% of the participants were found with mild, moderate and severe pain respectively, however 25% of the patients with osteoarthritis had no pain in the knee joints.

Table 7: Severity of pain among the study participants

Severity of pain	Frequency	Percentage
No pain	10	25.0
Mild	07	17.5
Moderate	12	30.0
Severe	11	27.5
Total	40	100.0

Graph 7: Severity of pain among the study participants

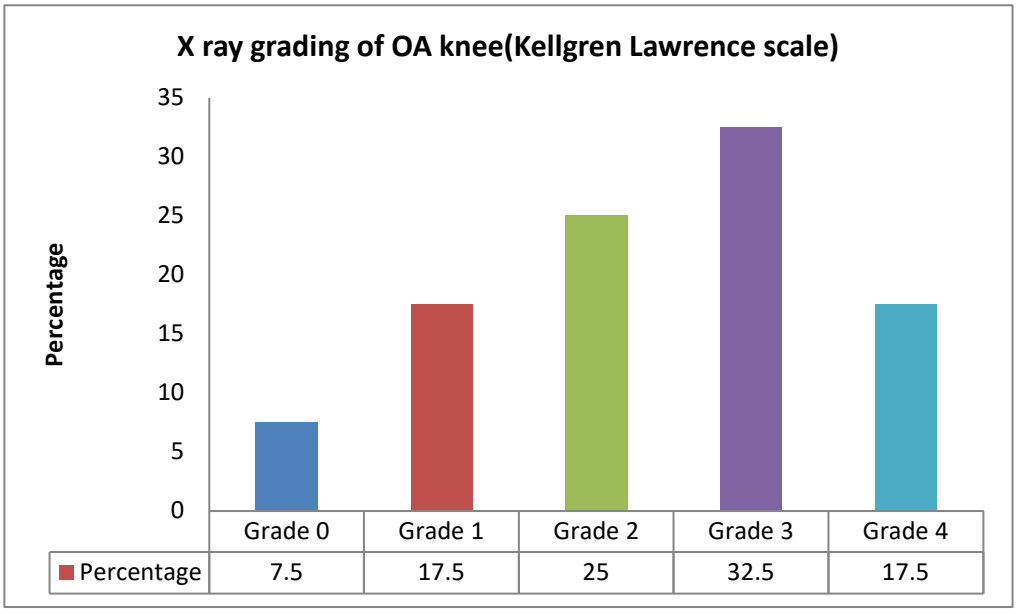


Based on the Kellgren Lawrence scale x ray findings of knee joint 7.5% of the participants were found with grade 0 OA knee, 17.5% participants were in grade 1 OA knee, 25% of the participants had grade 2 OA knee, 32.5% of the participants were found with grade 3 OA knee and 17.5% of the participants had grade 4 OA knee.

Table 8: Xray findings of OA knee based on Kellgren Lawrence scale

X ray grading of OA knee (Kellgren Lawrence scale)	Frequency	Percentage
Grade 0	03	7.5
Grade 1	07	17.5
Grade 2	10	25.0
Grade 3	13	32.5
Grade 4	07	17.5
Total	40	100.0

Graph 8: Xray findings of OA knee based on Kellgren Lawrence scale

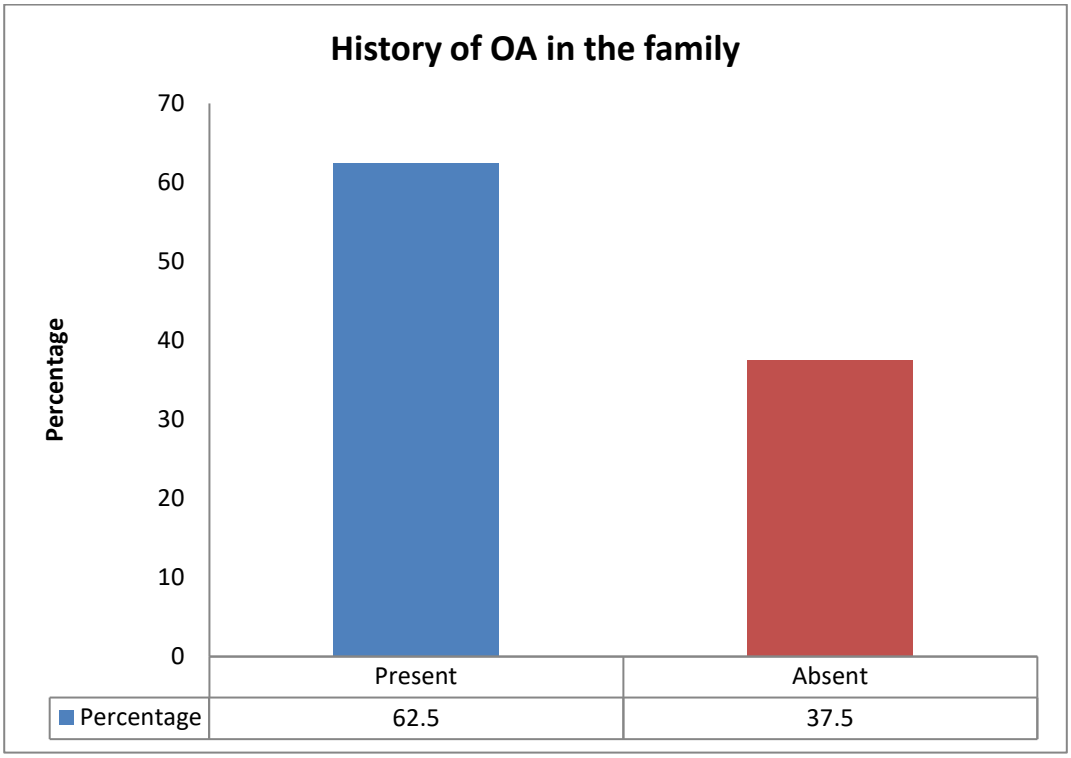


Among 62.5% of the participants, family history of OA knee was recorded while in 37.5% of the participants there was no family history of OA knee.

Table 9: Family history of OA knee

History of OA in the family	Frequency	Percentage
Present	25	62.5
Absent	15	37.5
Total	40	100.0

Graph 9: Family history of OA knee

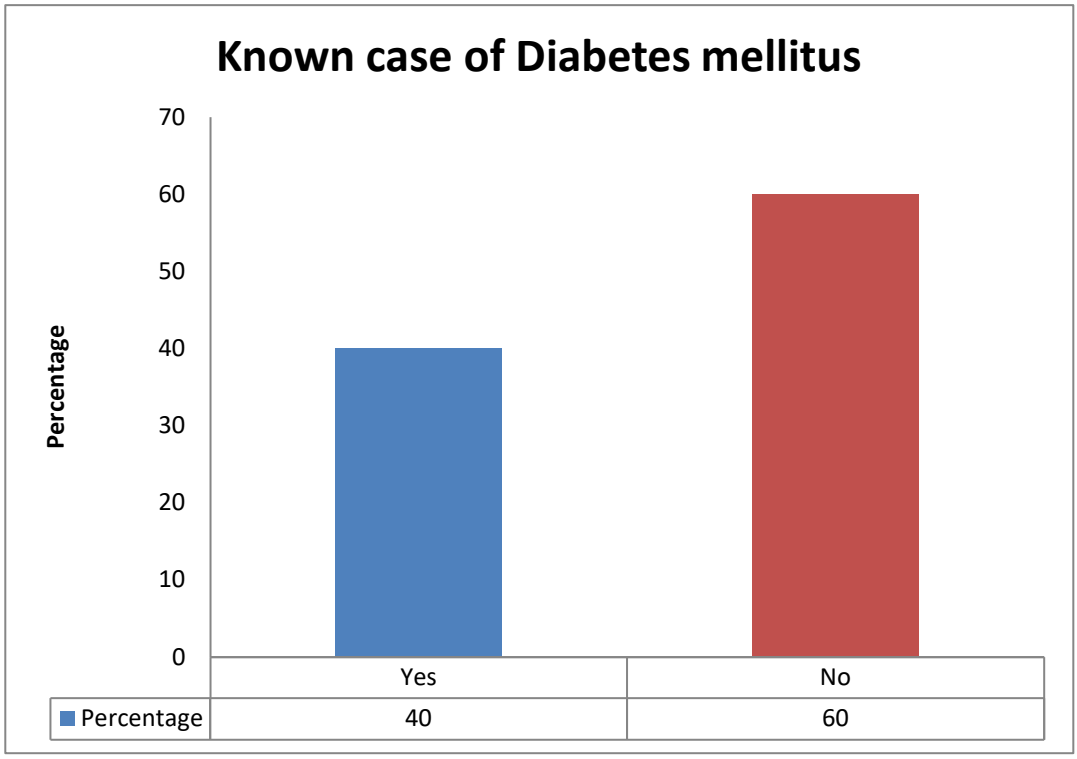


In this present study 40% of the patients were known diabetics whereas 60% of the participants were normal.

Table 10: Diabetes Mellitus among the study participants

Known case of Diabetes mellitus	Frequency	Percentage
Yes	16	40.0
No	24	60.0
Total	40	100.0

Graph 10: Diabetes Mellitus among the study participants

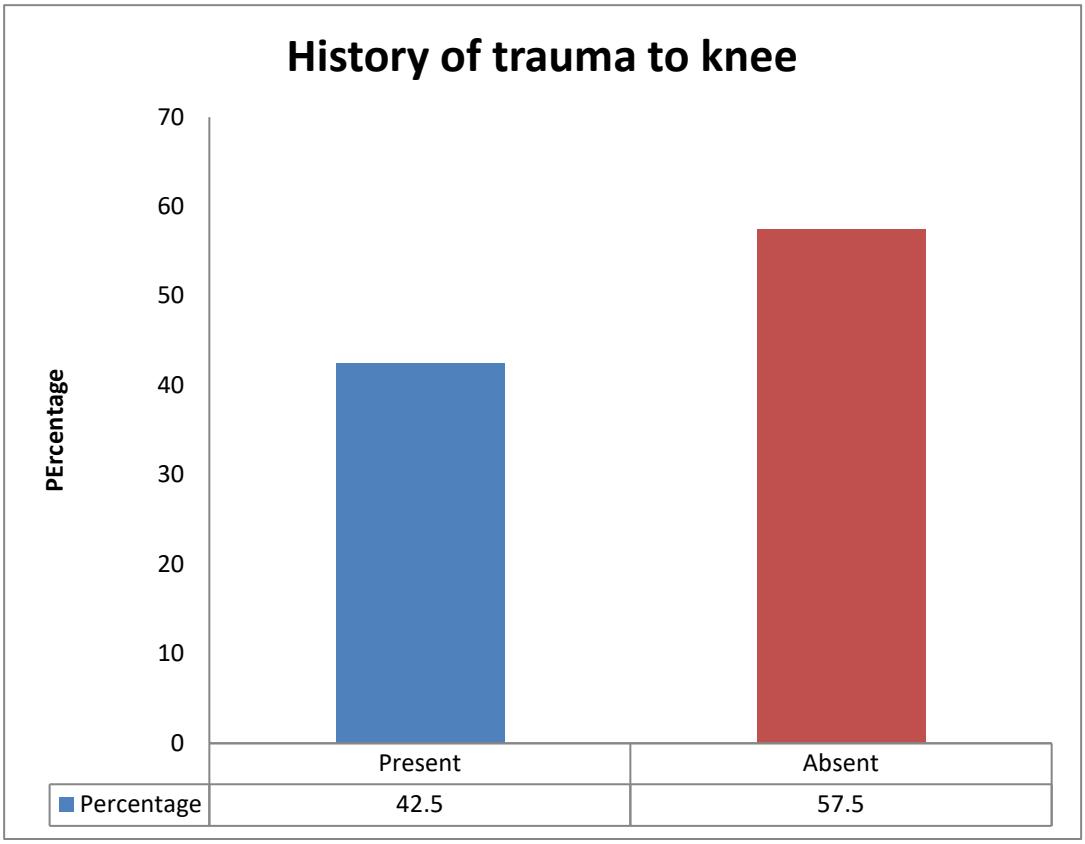


History of trauma to knee was recorded among 42.5% of the participants in this study whereas 57.5% of the study participants had no trauma history to the knee.

Table 11: Trauma to knee among the study participants

History of trauma to knee	Frequency	Percentage
Present	17	42.5
Absent	23	57.5
Total	40	100.0

Graph 11: Trauma to knee among the study participants

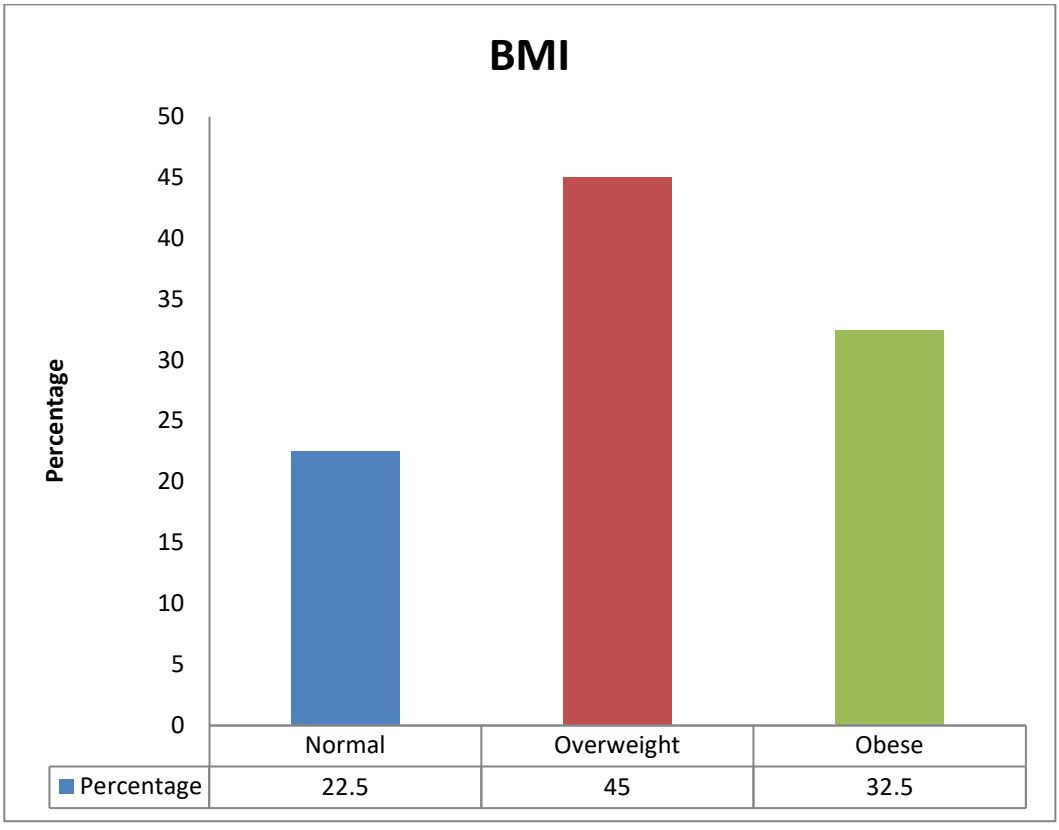


Regarding BMI, maximum (45%) of the participants was found tobe overweight while 32% of the participants were noted to be obese and 22.5% of the participants were normal in this study.

Table 12: Body Mass Index of the study participants

BMI	Frequency	Percentage
Normal	09	22.5
Overweight	18	45.0
Obese	13	32.5
Total	40	100.0

Graph 12: Body Mass Index of the study participants

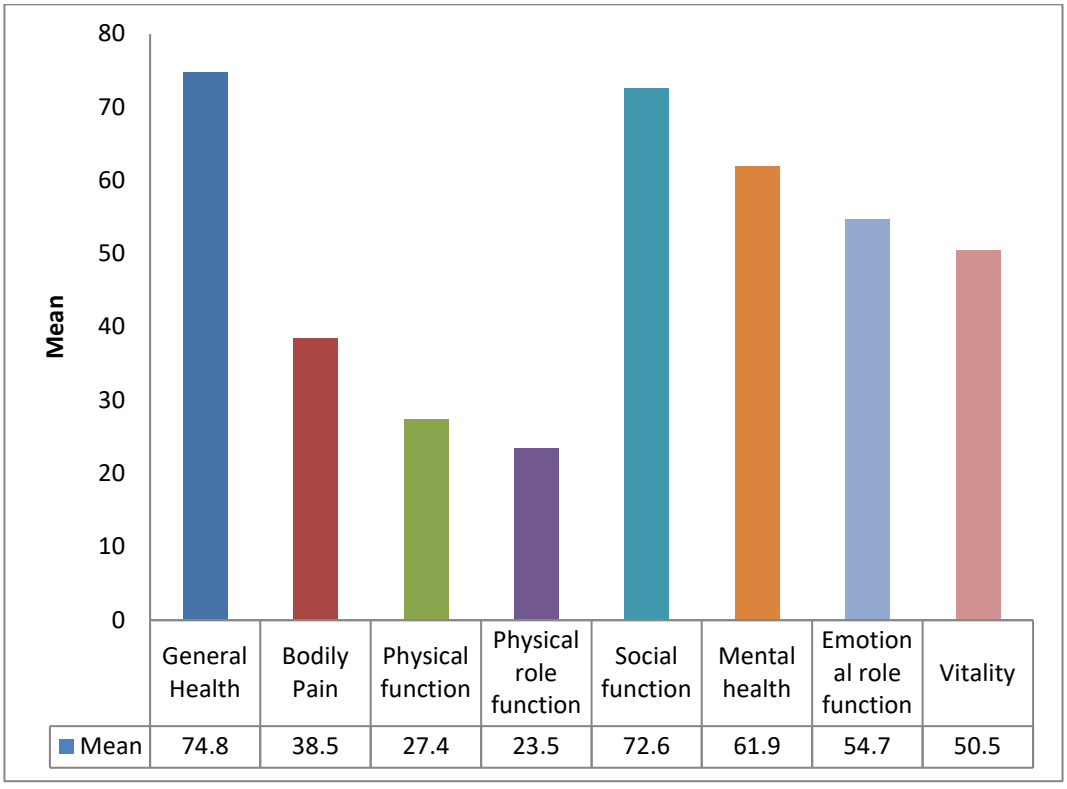


The mean general health parameter among the study participants was found to be 74.8 ± 12.2, the mean bodily pain was noted to be 38.5 ± 13.8, the mean physical function was 27.4± 15.7 and the mean physical role function was 23.5 ± 10.2. Among the study patients mean mental health was 61.9± 23.5, the mean emotional role function was 54.7 ± 30.2 and the mean vitality was noted to be 50.5 ± 24.7.

Table 13: Mean and SD of general health parameters of the study participants

Parameter	Mean	Std. Deviation
General Health	74.8	12.2
Bodily Pain	38.5	13.8
Physical function	27.4	15.7
Physical role function	23.5	10.2
Social function	72.6	21.2
Mental health	61.9	23.5
Emotional role function	54.7	30.2
Vitality	50.5	24.7

Graph 13: Mean and SD of general health parameters of the study participants



The mean and standard deviation of the temporal parameter based on gait analysis on right and left side leg were given in the table.

Table 14: Temporal and Spatial parameters on gait analysis

Parameter	Mean	Std. Deviation
Stride Time R (s)	1.55	0.74
Stride Time L (s)	1.53	0.59
Stance time R (s)	1.09	0.65
Stance time L (s)	1.06	0.60
Swing time R (s)	0.44	0.07
Swing time L (s)	0.45	0.07
Single Support Phase R (%)	33.09	7.49
Single Support Phase L (%)	32.17	8.34
Double Support Phase R (%)	19.97	12.03
Double Support Phase L (%)	16.68	8.95
Mean Velocity (m/s)	0.70	.030
Mean Velocity (%)	40.49	18.08
Cadence (steps/min)	88.44	20.93
Stride Length R (m)	0.90	0.30
Stride Length L (m)	0.86	0.26
Step length R (m)	0.46	0.14
Step length L (m)	0.44	0.13
Step width R (m)	0.14	0.06
Step width L (m)	0.14	0.06

In this current study the mean and standard deviation of kinematic parameters and the parameters in the reporting phase are given in the table.

Table 15: kinematic parameters and the parameters in the reporting phase

Parameter	Mean	Std. Deviation
Hip Flexion Extension R (degree)	7.75	9.87
Hip Flexion Extension L (degree)	7.74	11.15
Knee Flexion Extension R (degree)	0.48	7.93
Knee Flexion Extension L (degree)	1.62	9.67
Gait Profile Score R (degree)	11.96	6.04
Gait Profile Score L (degree)	12.65	4.98
Gait Deviation Index R	78.59	11.35
Gait Deviation Index L	75.88	10.55

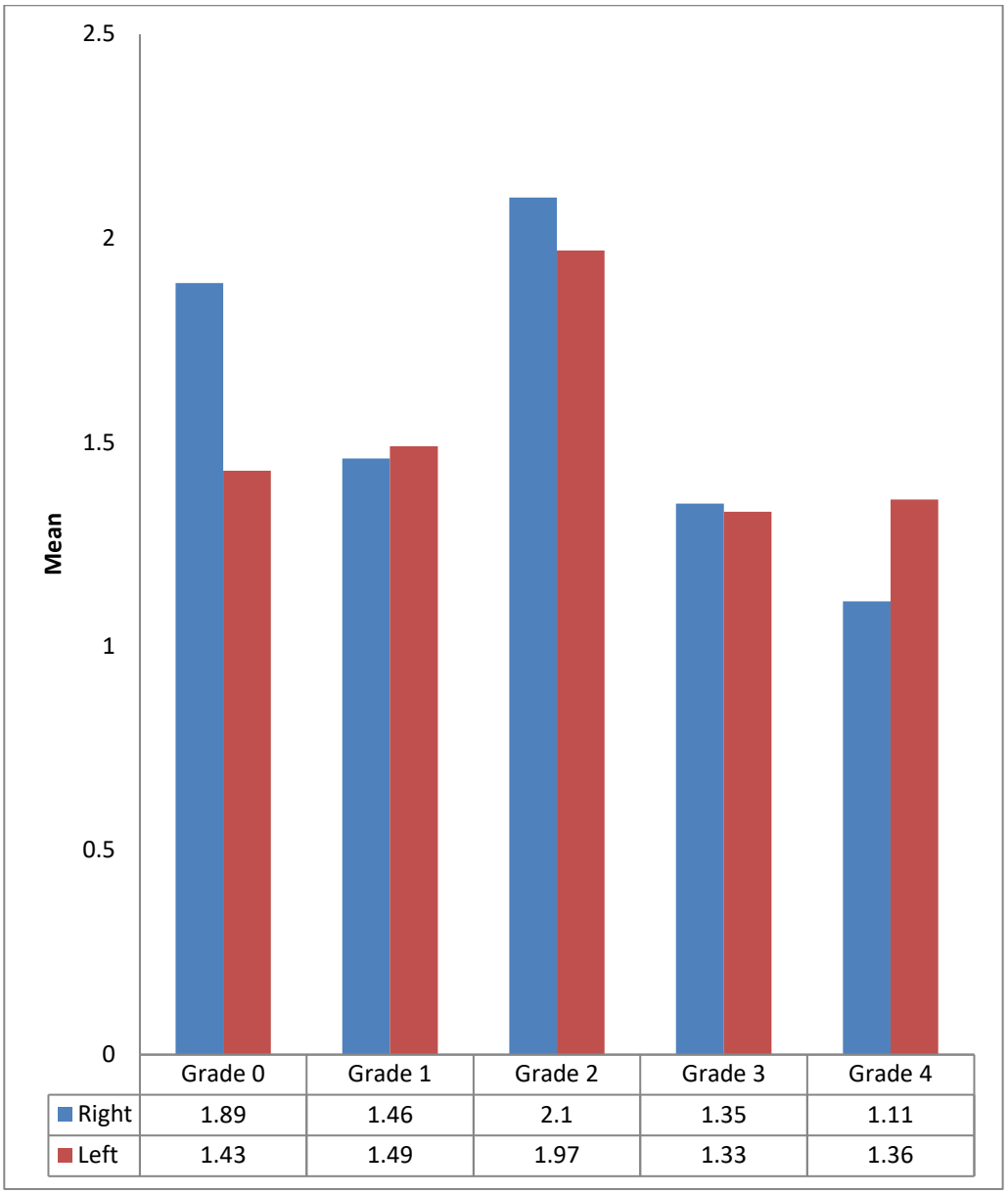
A statistically significant association recorded in this study for Stride time with respects to grading of OA knee on the right side leg with p value as 0.042, while the association for Stride time with respects to grading of OA knee on the left leg was not significant statistically with p value 0.094.

Table 16: Association between Stride Time (s) and OA knee grading

Grade of OA	Right		Left	
	Mean	SD	Mean	SD
Grade 0	1.89	1.20	1.43	0.48
Grade 1	1.46	0.81	1.49	0.74
Grade 2	2.10	0.93	1.97	0.85
Grade 3	1.35	0.24	1.33	0.20
Grade 4	1.11	0.49	1.36	0.25
Total	1.55	0.75	1.53	0.60
P value	0.042*		0.094	

*Significant

Graph 14: Association between Stride Time (s) and OA knee grading



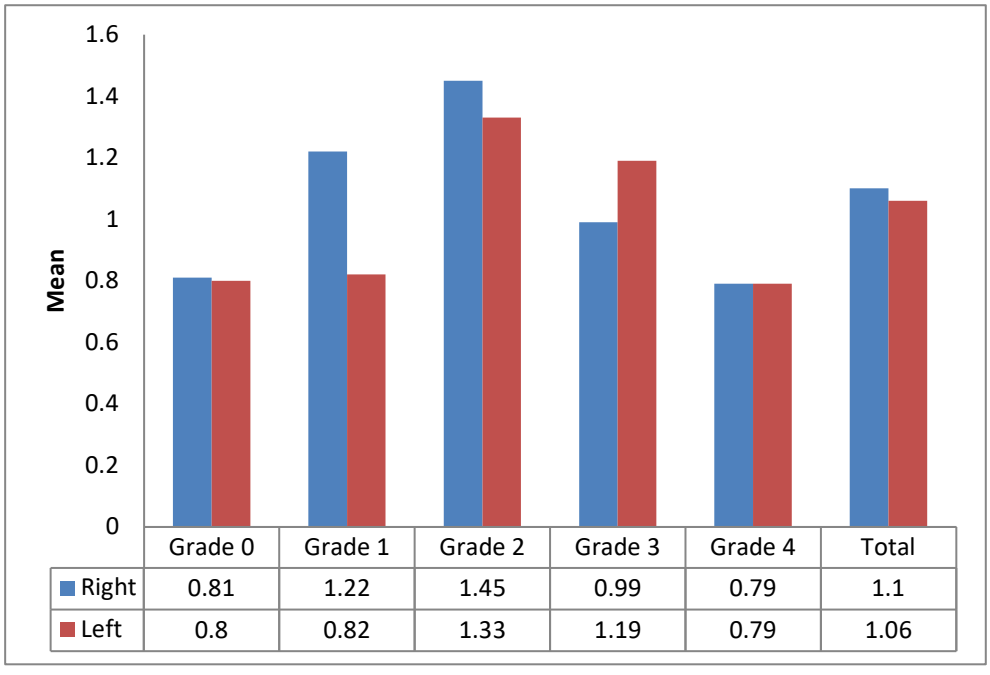
	Grade 0	Grade 1	Grade 2	Grade 3	Grade 4
Right	1.89	1.46	2.1	1.35	1.11
Left	1.43	1.49	1.97	1.33	1.36

Meanwhile the association between grading of OA and the stance time on the right and left side leg was found to be statistically insignificant with p value noted as 0.237 and 0.218 respectively.

Table 17: Association between Stance time (s) and OA knee grading

Grade of OA	Right		Left	
	Mean	SD	Mean	SD
Grade 0	0.81	0.10	0.80	0.12
Grade 1	1.22	0.85	0.82	0.28
Grade 2	1.45	0.82	1.33	0.77
Grade 3	0.99	0.57	1.19	0.71
Grade 4	0.79	0.16	0.79	0.15
Total	1.10	0.66	1.06	0.60
P value	0.237		0.218	

Graph 15: Association between Stance time (s) and OA knee grading

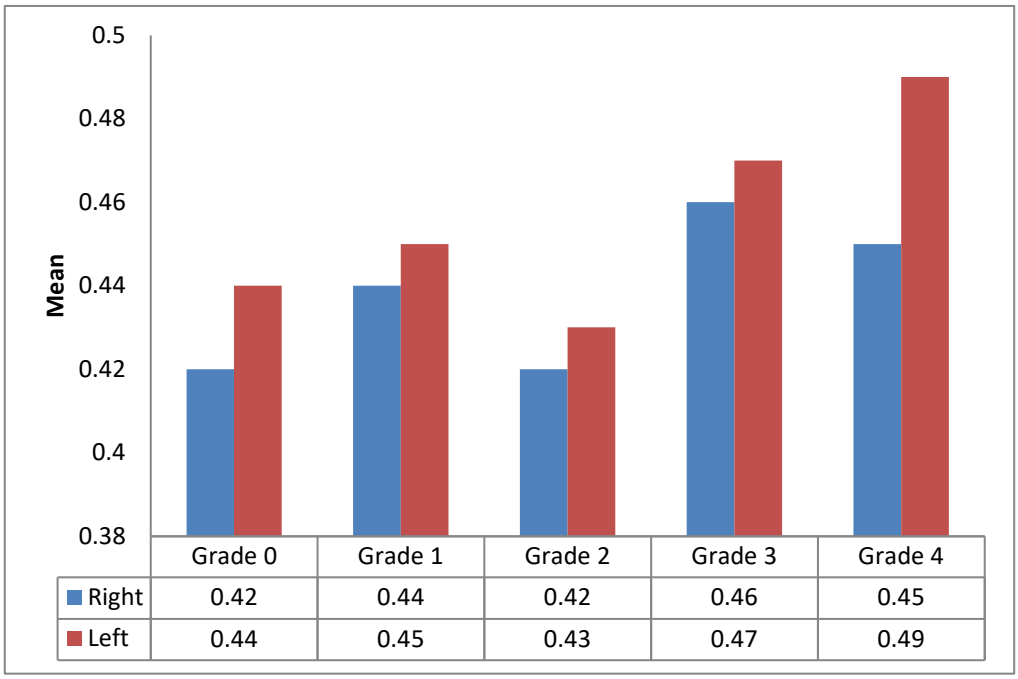


On assessing the association between swing time and the grading of OA knee, there was no association between the two on both the sides leg with statistical insignificance and the p value was 0.703 on the right side and 0.585 on the left side.

Table 18: Association between Swing time (s) and OA knee grading

Grade of OA	Right		Left	
	Mean	SD	Mean	SD
Grade 0	0.42	0.02	0.44	0.04
Grade 1	0.44	0.04	0.45	0.04
Grade 2	0.42	0.08	0.43	0.09
Grade 3	0.46	0.04	0.47	0.07
Grade 4	0.45	0.13	0.49	0.09
Total	0.44	0.07	0.46	0.07
P value	0.703		0.585	

Graph 16: Association between Swing time (s) and OA knee grading



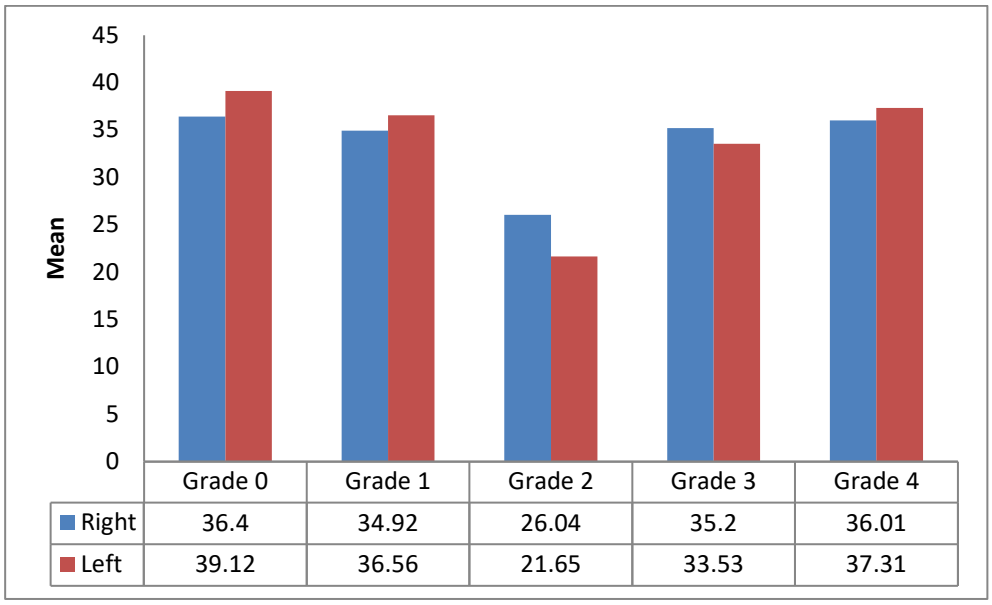
In this study the association between Single Support Phase and the grading of OA knee, there was statistically significant association found between Single Support Phase on the right and left side and grading of OA knee.

Table 19: Association between Single Support Phase (%) and OA knee grading

Grade of OA	Right		Left	
	Mean	SD	Mean	SD
Grade 0	36.40	2.22	39.12	3.19
Grade 1	34.92	6.19	36.56	1.17
Grade 2	26.04	10.40	21.65	9.34
Grade 3	35.20	4.76	33.53	4.54
Grade 4	36.01	2.41	37.31	3.14
Total	33.09	7.50	32.17	8.34
P value	0.011*		0.000*	

*Significant

Graph 17: Association between Single Support Phase (%) and OA knee grading



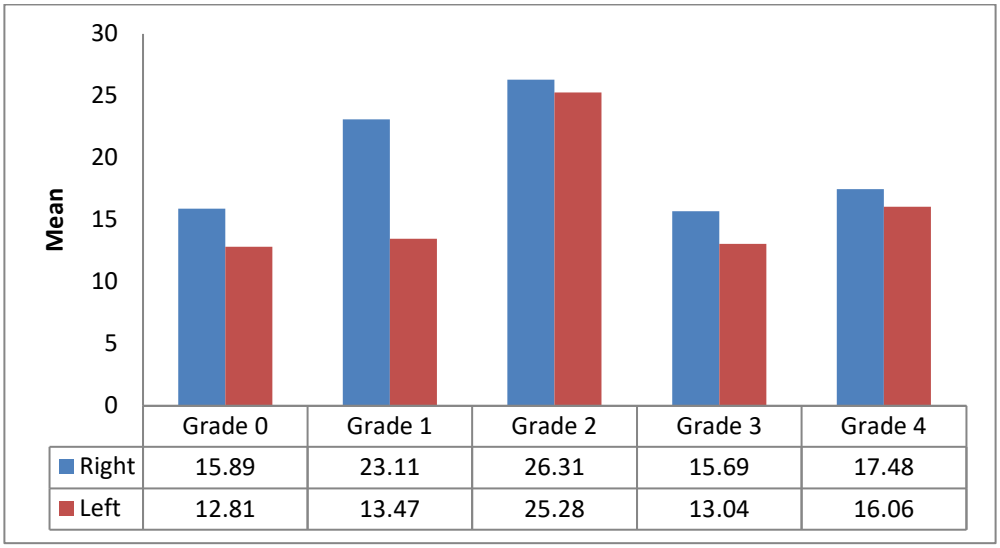
There was no association found between Double Support Phase and OA knee grading on the right side knee whereas significant statistical association recorded betweenDouble Support Phase and OA knee grading on the left side knee with p value 0f 0.006.

Table 20: Association between Double Support Phase (%) and OA knee grading

Grade of OA	Right		Left	
	Mean	SD	Mean	SD
Grade 0	15.89	3.89	12.81	0.65
Grade 1	23.11	16.39	13.47	3.07
Grade 2	26.31	17.67	25.28	11.54
Grade 3	15.69	2.20	13.04	4.60
Grade 4	17.48	7.51	16.06	9.92
Total	19.97	12.04	16.69	8.96
P value	0.239		0.006*	

*Significant

Graph 18: Association between Double Support Phase (%) and OA knee grading



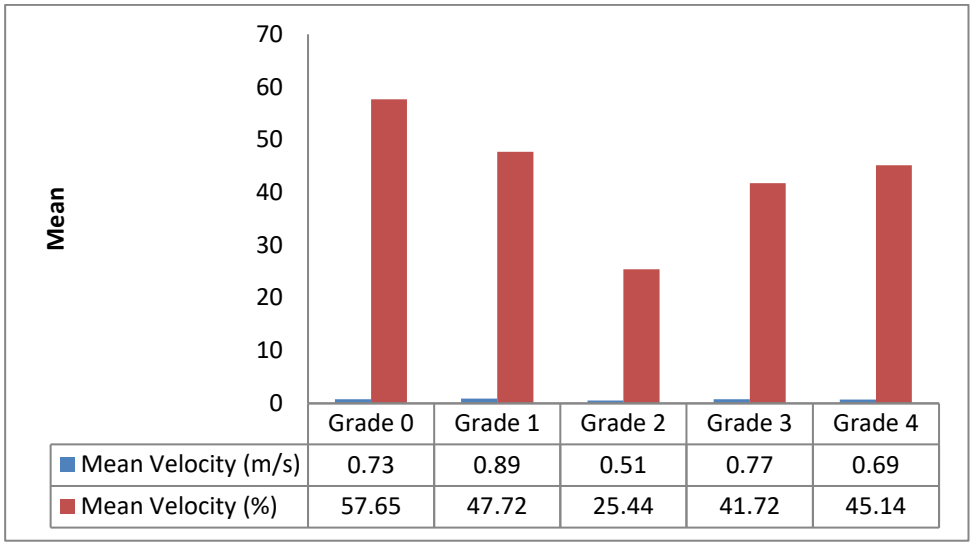
In this present study the association between Mean Velocityand the grading of OA knee, there was no statistically significant association found between Mean Velocityon the right side and grading of OA knee however statistically significant association noted on the left side mean velocity and grading of OA knee with p value of 0.015.

Table 21: Association between Mean Velocity (m/s)and OA knee grading

Grade of OA	Mean Velocity (m/s) Right		Mean Velocity (%) Left	
	Mean	SD	Mean	SD
Grade 0	0.73	0.46	57.65	3.57
Grade 1	0.89	0.22	47.72	18.07
Grade 2	0.51	0.30	25.44	18.37
Grade 3	0.77	0.26	41.72	15.45
Grade 4	0.69	0.31	45.14	14.04
Total	0.71	0.30	40.49	18.08
P value	0.118		0.015*	

*Significant

Graph 19: Association between Mean Velocity (m/s)and OA knee grading

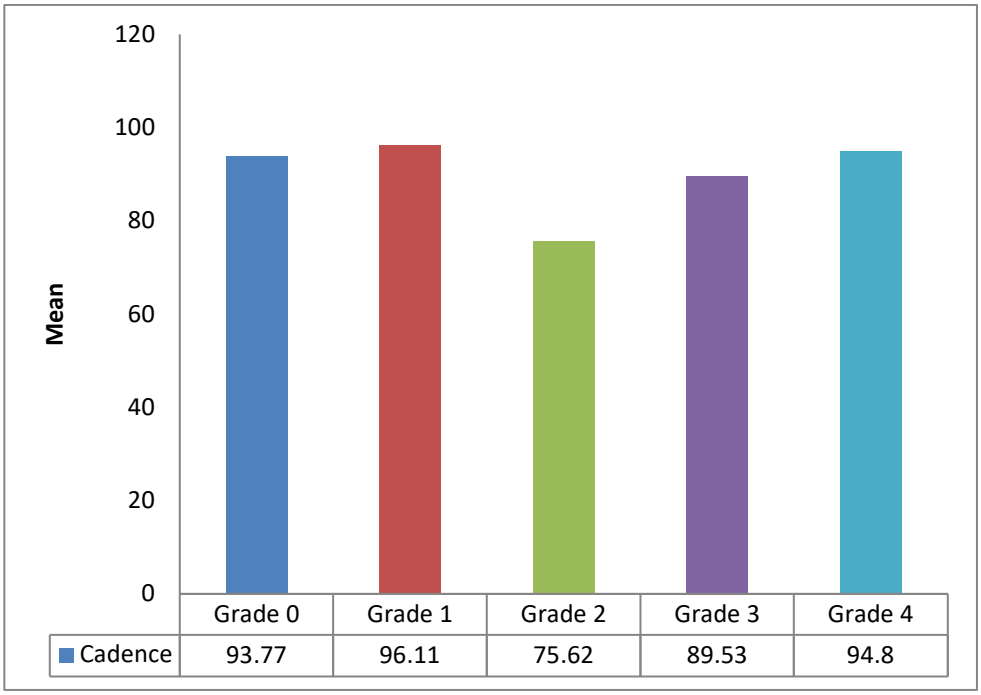


Regarding Cadence (steps/min) and OA knee grading there was no significant statistical association in this study, the p value was recorded as 0.236.

Table 22: Association between Cadence (steps/min) and OA knee grading

Grade of OA	Cadence	
	Mean	SD
Grade 0	93.77	9.08
Grade 1	96.11	18.81
Grade 2	75.62	26.13
Grade 3	89.53	18.79
Grade 4	94.80	18.21
Total	88.45	20.94
P value	0.236	

Graph 20: Association between Cadence (steps/min) and OA knee grading



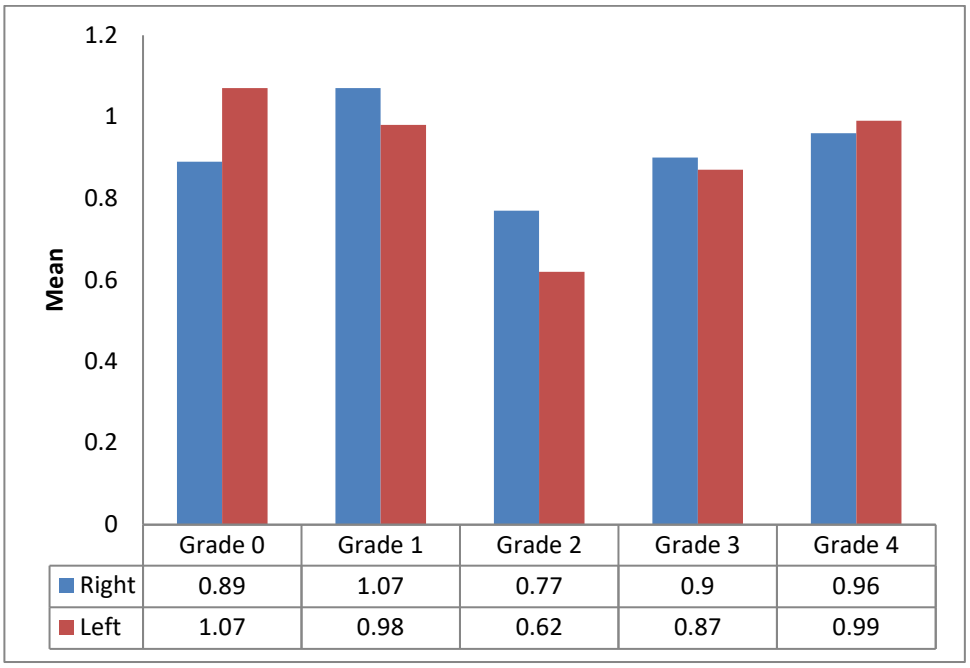
Based on the stride length on the right and left side, left side alone statistically significant association was found for stride length and OA knee grading with p value 0.007.

Table 23: Association between Stride Length (m)and OA knee grading

Grade of OA	Right		Left	
	Mean	SD	Mean	SD
Grade 0	0.89	0.26	1.07	0.10
Grade 1	1.07	0.27	0.98	0.30
Grade 2	0.77	0.38	0.62	0.25
Grade 3	0.90	0.29	0.87	0.19
Grade 4	0.96	0.25	0.99	0.23
Total	0.91	0.31	0.86	0.27
P value	0.413		0.007*	

*Significant

Graph 21: Association between Stride Length (m)and OA knee grading



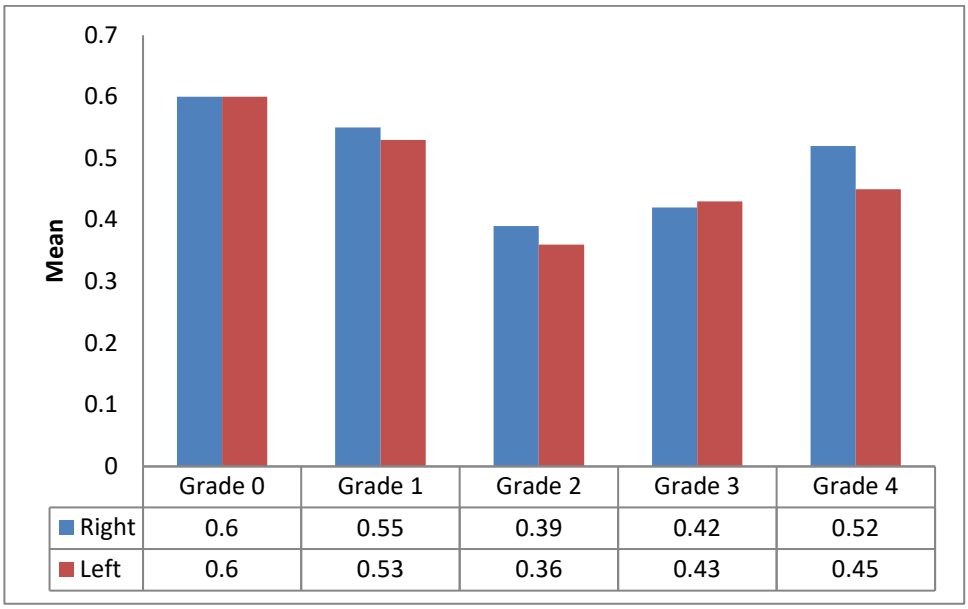
The association between step length and grading of OA knee was noted as statistically significant on both sides with significant p values <0.05, as shown in the table.

Table 24: Association between Step length (m)and OA knee grading

Grade of OA	Right		Left	
	Mean	SD	Mean	SD
Grade 0	0.60	0.02	0.60	0.05
Grade 1	0.55	0.12	0.53	0.11
Grade 2	0.39	0.16	0.36	0.16
Grade 3	0.42	0.14	0.43	0.10
Grade 4	0.52	0.10	0.45	0.11
Total	0.47	0.14	0.44	0.13
P value	0.029*		0.020*	

*Significant

Graph 22: Association between Step length (m)and OA knee grading

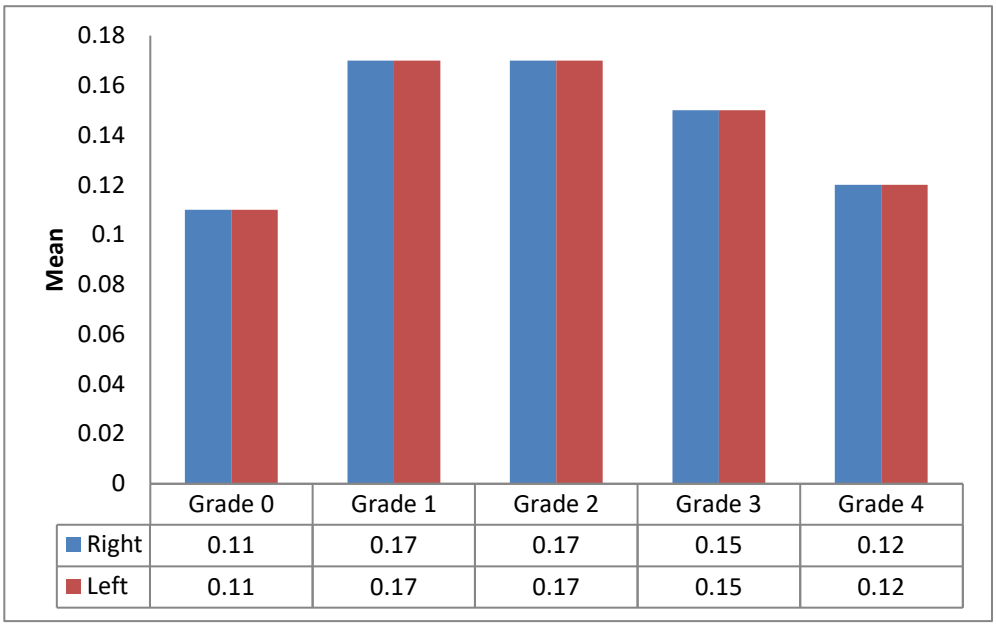


The association between step width and grading of OA knee was noted to be not statistically significant on right and left side, as shown in the table.

Table 25: Association between Step width (m)and OA knee grading

Grade of OA	Right		Left	
	Mean	SD	Mean	SD
Grade 0	0.11	0.05	0.11	0.05
Grade 1	0.17	0.08	0.17	0.08
Grade 2	0.17	0.07	0.17	0.07
Grade 3	0.15	0.06	0.15	0.06
Grade 4	0.12	0.03	0.12	0.03
Total	0.15	0.06	0.15	0.06
P value	0.398		0.398	

Graph 23: Association between Step width (m)and OA knee grading

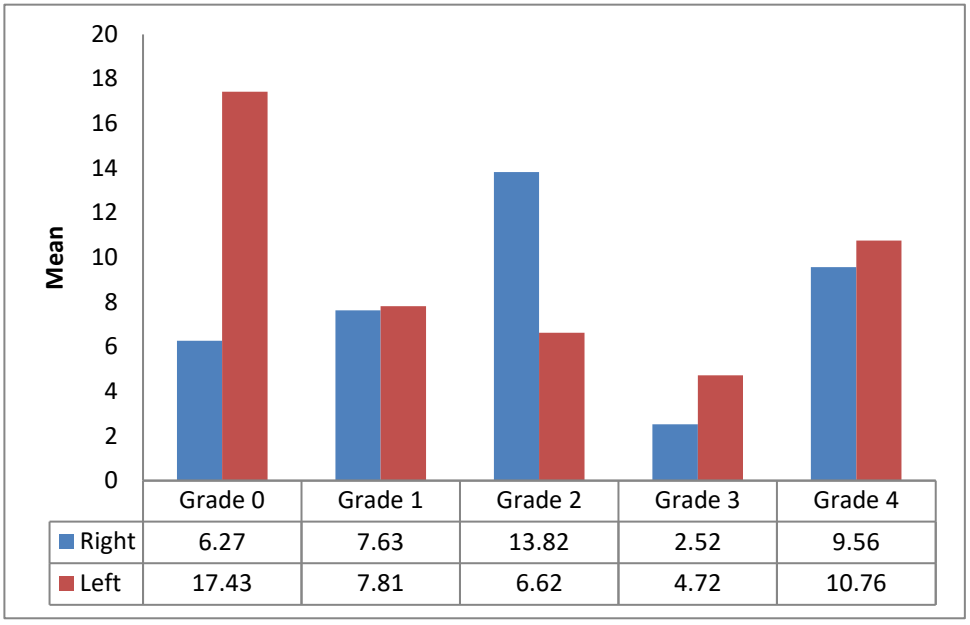


In this current study the kinematic parameter hip flexion extension on the right leg is statistically insignificant with OA grading and on the left side also there was no association found for hip flexion extension and OA grading , p value >0.05.

Table 26: Association between Hip Flexion Extension (in degree) and OA knee grading

Grade of OA	Right		Left	
	Mean	SD	Mean	SD
Grade 0	6.27	4.91	17.43	8.99
Grade 1	7.63	6.21	7.81	12.52
Grade 2	13.82	10.94	6.62	13.89
Grade 3	2.52	10.03	4.72	8.91
Grade 4	9.56	9.02	10.76	9.88
Total	7.75	9.88	7.75	11.15
P value	0.094		0.445	

Graph 24: Association between Hip Flexion Extension (in degree) and OA knee grading



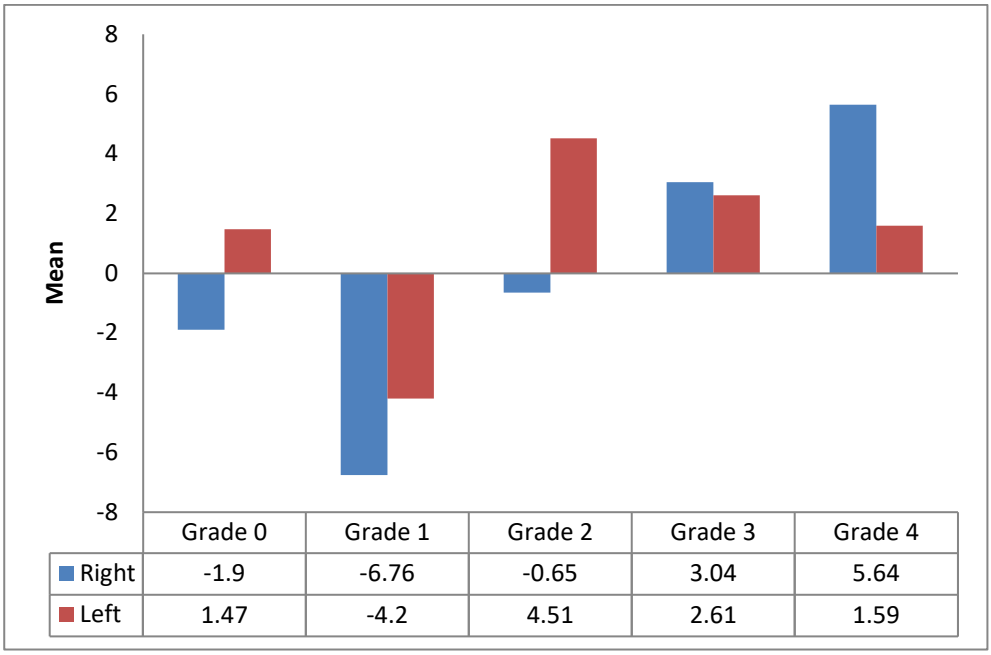
Based on the Knee Flexion Extension on the right and left side, right side alone had statistically significant association for Knee Flexion Extension and OA knee grading.

Table 27: Association between Knee Flexion Extension (degree)and OA knee grading

Grade of OA	Right		Left	
	Mean	SD	Mean	SD
Grade 0	-1.90	12.84	1.47	10.69
Grade 1	-6.76	4.03	-4.20	9.01
Grade 2	-0.65	4.80	4.51	6.83
Grade 3	3.04	7.23	2.61	12.66
Grade 4	5.64	9.33	1.59	6.60
Total	0.49	7.93	1.63	9.68
P value	0.022*		0.487	

*Significant

Graph 25: Association between Knee Flexion Extension (degree)and OA knee grading

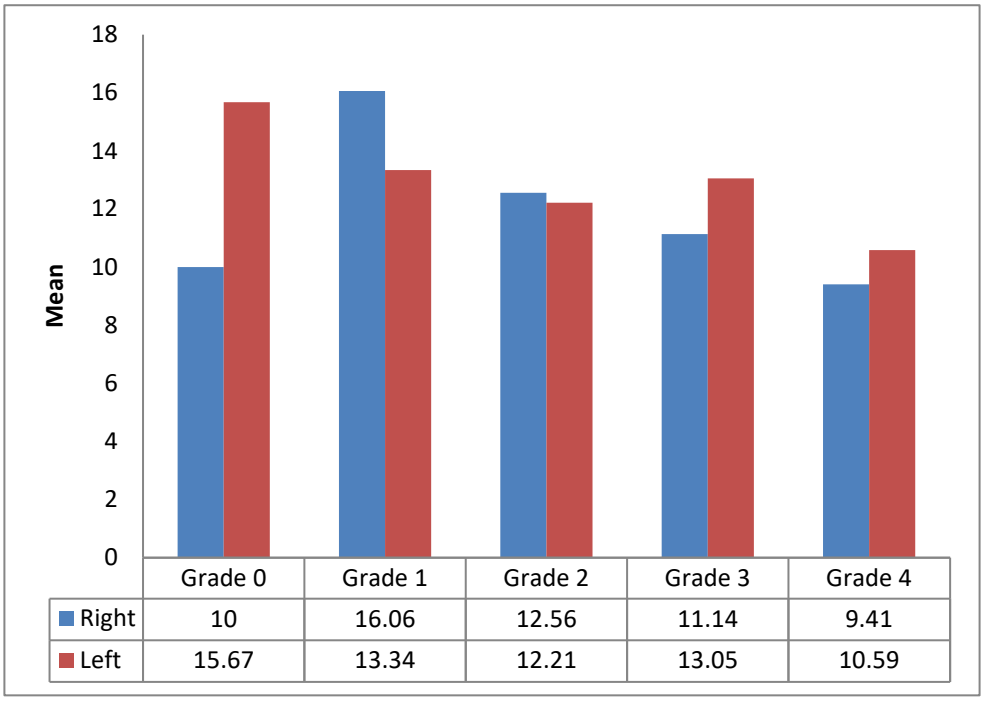


There was no statistically significant association found between grading of OA knee and Gait Profile Score in the reporting phase on right and left side, as shown in the table.

Table 28: Association between Gait Profile Score (degree)and OA knee grading

Grade of OA	Right		Left	
	Mean	SD	Mean	SD
Grade 0	10.00	2.44	15.67	8.66
Grade 1	16.06	10.23	13.34	5.87
Grade 2	12.56	4.83	12.21	4.22
Grade 3	11.14	5.03	13.05	5.26
Grade 4	9.41	3.74	10.59	3.08
Total	11.97	6.04	12.66	4.99
P value	0.282		0.649	

Graph 26: Association between Gait Profile Score (degree)and OA knee grading

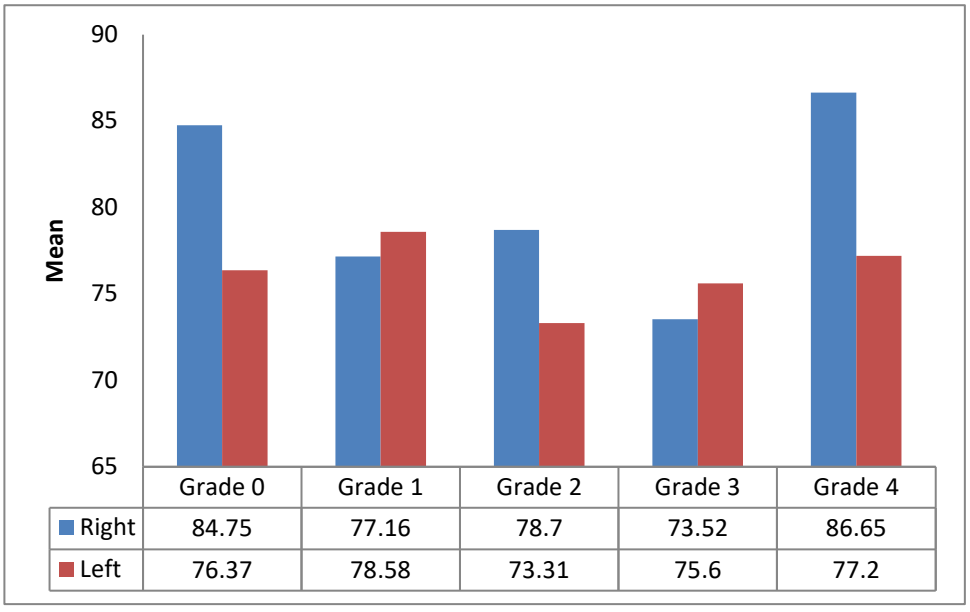


Likewise there was no statistically significant association found between grading of OA knee and Gait Deviation Indexin the reporting phase on right and left side, as shown in the table.

Table 29: Association between Gait Deviation Indexand OA knee grading

Grade of OA	Right		Left	
	Mean	SD	Mean	SD
Grade 0	84.75	4.34	76.37	6.15
Grade 1	77.16	12.59	78.58	10.80
Grade 2	78.70	11.96	73.31	9.69
Grade 3	73.52	10.24	75.60	12.86
Grade 4	86.65	9.82	77.20	10.09
Total	78.59	11.36	75.89	10.56
P value	0.123		0.894	

Graph 27: Association between Gait Deviation Indexand OA knee grading

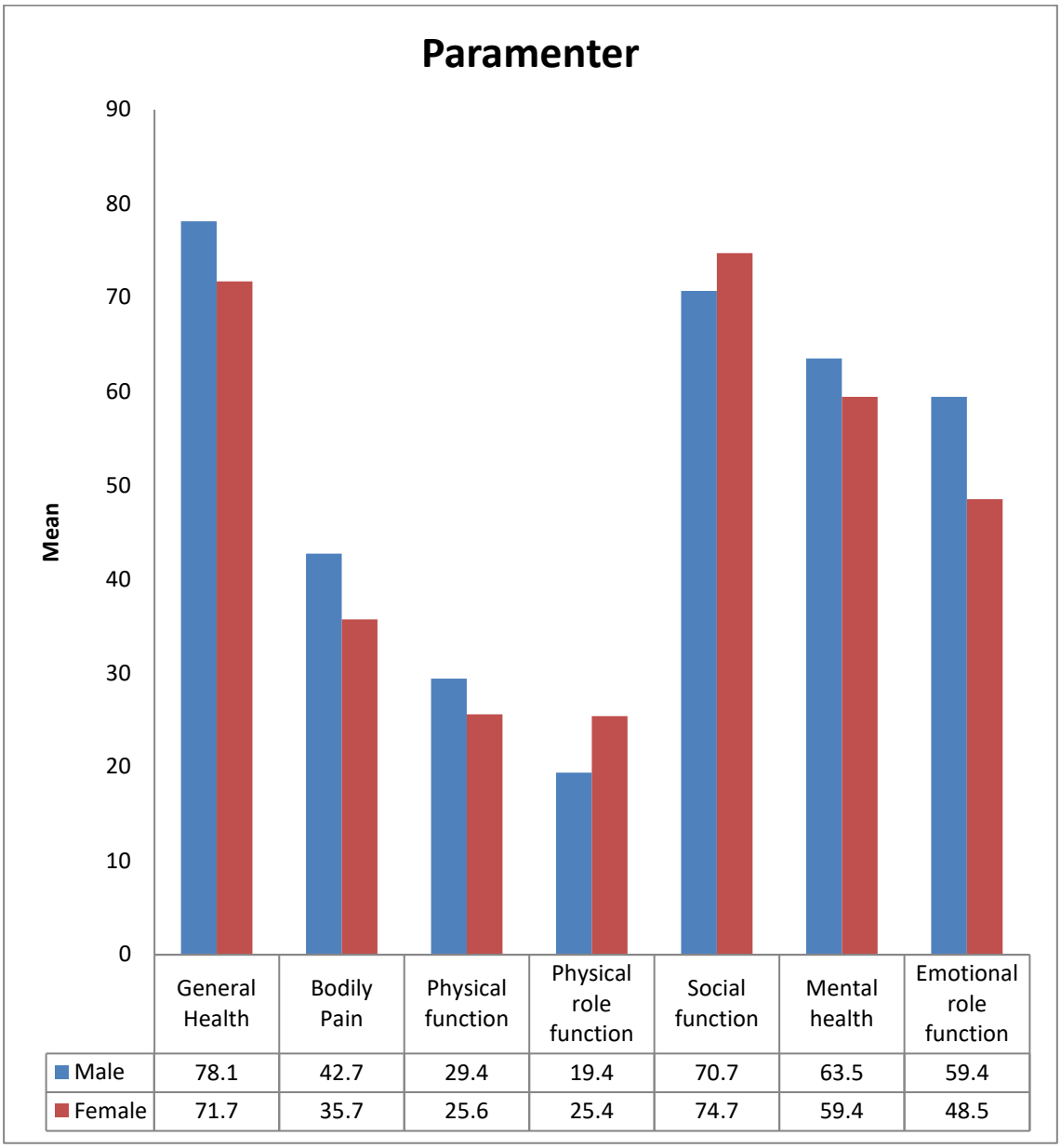


The mean general health among male and female participants was 78.1±11.5 and 71.7±13.4respectively, but the difference between males and females for general health wellbeing was not statistically significant with p value 0.117. Likewise there was no statistically significant difference noted between male and female participants for bodily pain (p value = 0.162), physical function (p value = 0.471), physical role function (p value = 0.084), social function (p value = 0.572), mental health (p value = 0.603), emotional role (p value = 0.274) and vitality (p value = 0.792), which shows there was no difference in the general and physical health based on gender for osteoarthritis.

Table 30: Difference in general health parameter based on gender

Parameter	Male	Female	P value
General Health	78.1±11.5	71.7±13.4	0.117
Bodily Pain	42.7±16.8	35.7±11.4	0.162
Physical function	29.4±15.8	25.6±15.1	0.471
Physical role function	19.4±9.5	25.4±11.7	0.084
Social function	70.7±22.3	74.7±20.1	0.572
Mental health	63.5±25.3	59.4±21.5	0.603
Emotional role function	59.4±26.7	48.5±35.1	0.274
Vitality	49.3±22.6	51.4±26.8	0.792

Table 28: Difference in general health parameter based on gender



	General Health	Bodily Pain	Physical function	Physical role function	Social function	Mental health	Emotional role function
Male	78.1	42.7	29.4	19.4	70.7	63.5	59.4
Female	71.7	35.7	25.6	25.4	74.7	59.4	48.5

Based on the stride time on the right side knee joints there was no significant statistical difference found between male and female participants with p value of 0.646, whereas the difference in stride time on the left side knee joint among male and female participants was noted to be statistically significant in this study (p value =0.002).

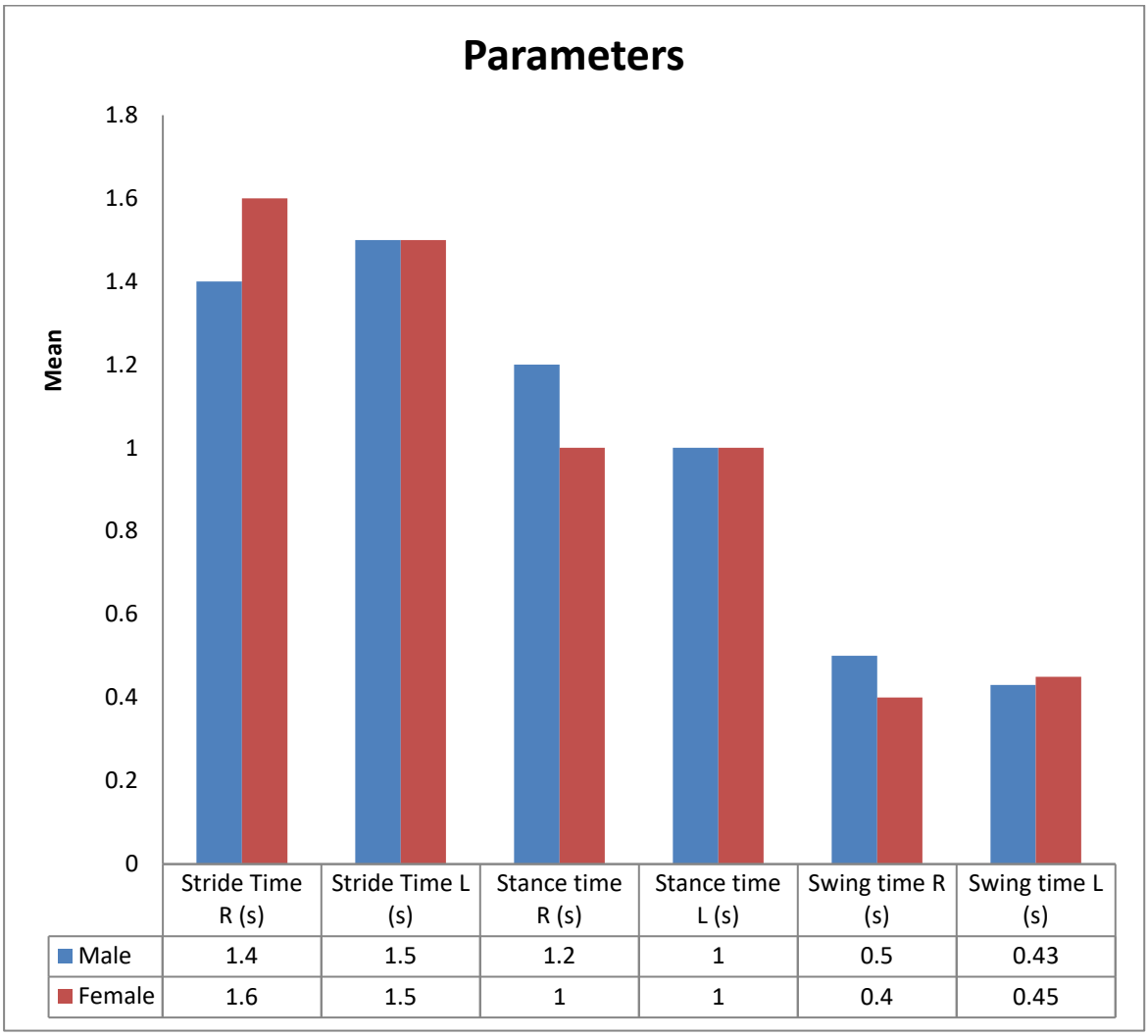
Regarding the stance time there was no statistically significant difference found between gender on both the right and left side knee with p values of 0.068 and 0.428 respectively. The difference in Swing time on the right and left side knee was also found to be statistically insignificant with p value on right side to be 0.422 and left side to be 0.788.

Table 31: Difference in Stride, Stance and Swing time among male and female participants

Parameter	Male	Female	P value
Stride Time R (s)	1.4±0.9	1.6±0.6	0.646
Stride Time L (s)	1.5±0.6	1.5±0.5	0.002*
Stance time R (s)	1.2±0.7	1.0±0.5	0.068
Stance time L (s)	1.0±0.6	1.0±0.7	0.428
Swing time R (s)	0.5±0.07	0.4±0.06	0.422
Swing time L (s)	0.43±0.07	0.45±0.07	0.788

*Significant

Graph 29: Difference in Stride, Stance and Swing time among male and female participants



	Stride Time R (s)	Stride Time L (s)	Stance time R (s)	Stance time L (s)	Swing time R (s)	Swing time L (s)
Male	1.4	1.5	1.2	1	0.5	0.43
Female	1.6	1.5	1	1	0.4	0.45

Temporal parameters based on gait analysis like Single Support Phase on the right knee was among the male and female participants was not statistically significant which shows there was no difference in Single Support Phase percentage based on gender whereas the difference in Single Support Phase on the left knee among both the gender was found to be statistically significant with p value of 0.023.

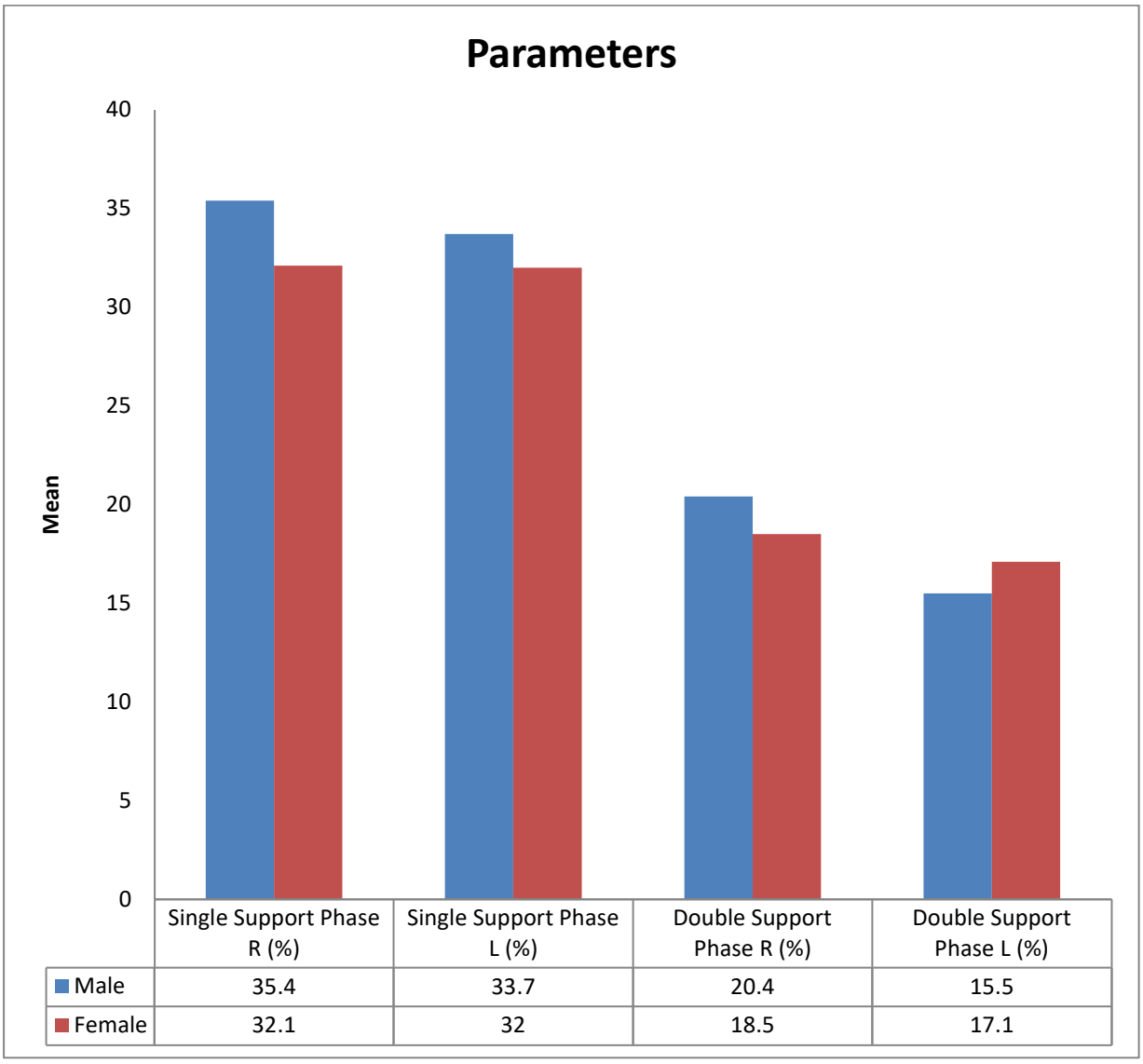
Double Support Phase on the right knee was insignificant with no difference between male and female participants while the difference in Double Support Phase on the left knee between male and female participants were statistically significant (p value =0.008).

Table 32: Gait analysis- single support and double support phase

Parameter	Male	Female	P value
Single Support Phase R (%)	35.4±6.4	32.1±9.4	0.246
Single Support Phase L (%)	33.7±8.3	32.0±7.5	0.023*
Double Support Phase R (%)	20.4±11.3	18.5±13.6	0.573
Double Support Phase L (%)	15.5±9.1	17.1±8.0	0.008*

*Significant

Table 30: Gait analysis- single support and double support phase



	Single Support Phase R (%)	Single Support Phase L (%)	Double Support Phase R (%)	Double Support Phase L (%)
Male	35.4	33.7	20.4	15.5
Female	32.1	32	18.5	17.1

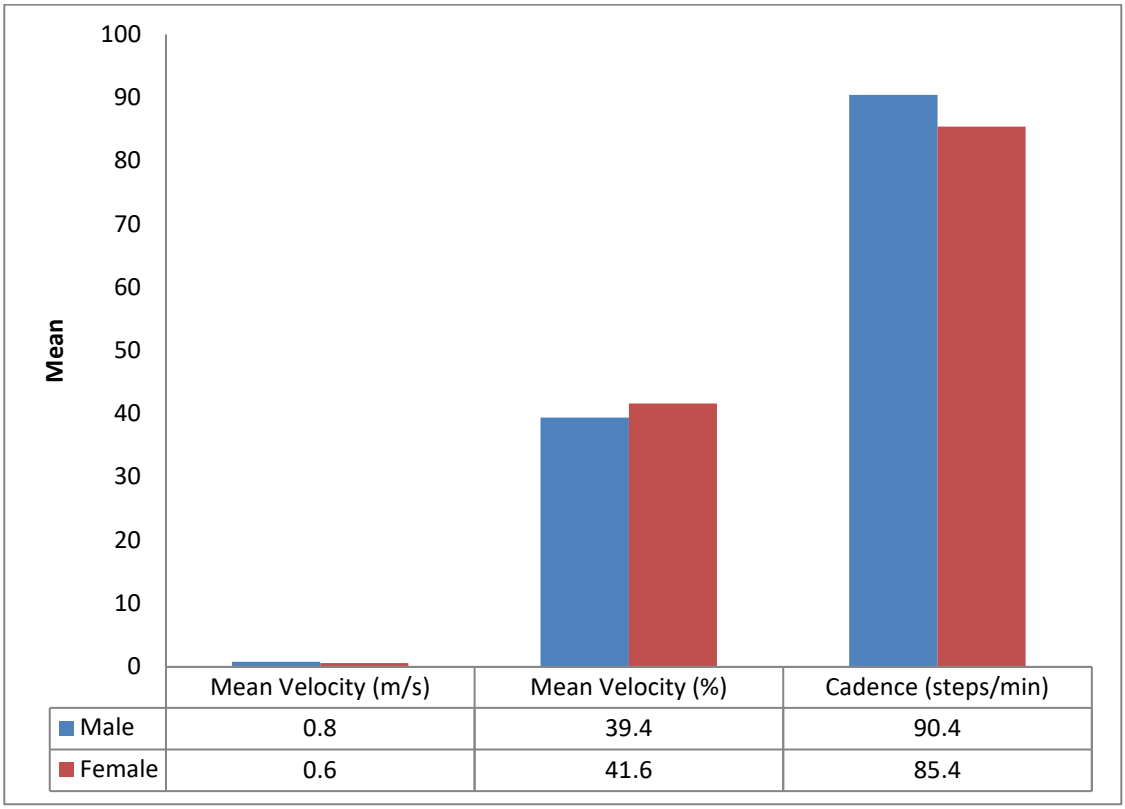
In this study based on the gait analysis there was statistical significant difference found between males and females for mean velocity in m/s with p value of 0.038 and cadence with p value of 0.031.

Table 33: Gait analysis- mean velocity and cadence

Parameter	Male	Female	P value
Mean Velocity (m/s)	0.8±0.3	0.6±0.4	0.038*
Mean Velocity (%)	39.4±17.5	41.6±22.8	0.107
Cadence (steps/min)	90.4±21.6	85.4±17.4	0.031*

*Significant

Graph 31: Gait analysis- mean velocity and cadence

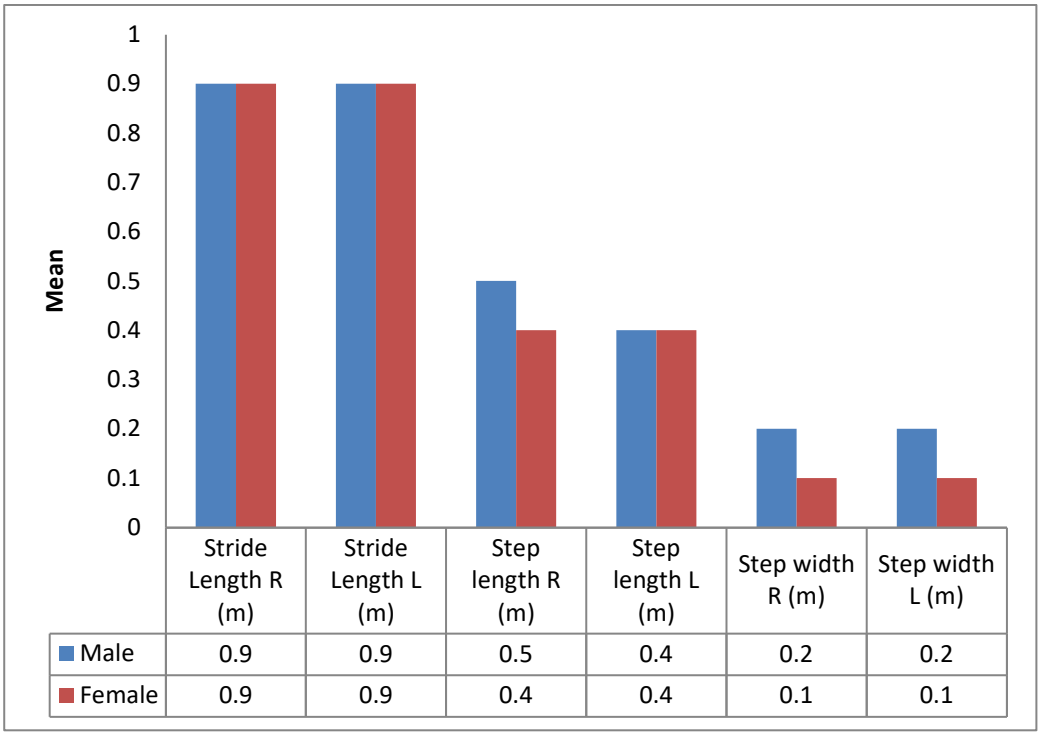


There was no significant difference found for spatial parameters like Stride Length, Step lengthand step width between male and female participants of this study on both side knees.

Table 34: Difference in Spatial parameter among the study participants based on gender

Parameter	Male	Female	P value
Stride Length R (m)	0.9±0.3	0.9±0.4	0.105
Stride Length L (m)	0.9±0.3	0.9±0.2	0.155
Step length R (m)	0.5±0.1	0.4±0.2	0.543
Step length L (m)	0.4±0.3	0.4±0.2	0.113
Step width R (m)	0.2±0.07	0.1±0.04	0.357
Step width L (m)	0.2±0.07	0.1±0.04	0.357

Graph 32: Difference in Spatial parameter among the study participants based on gender



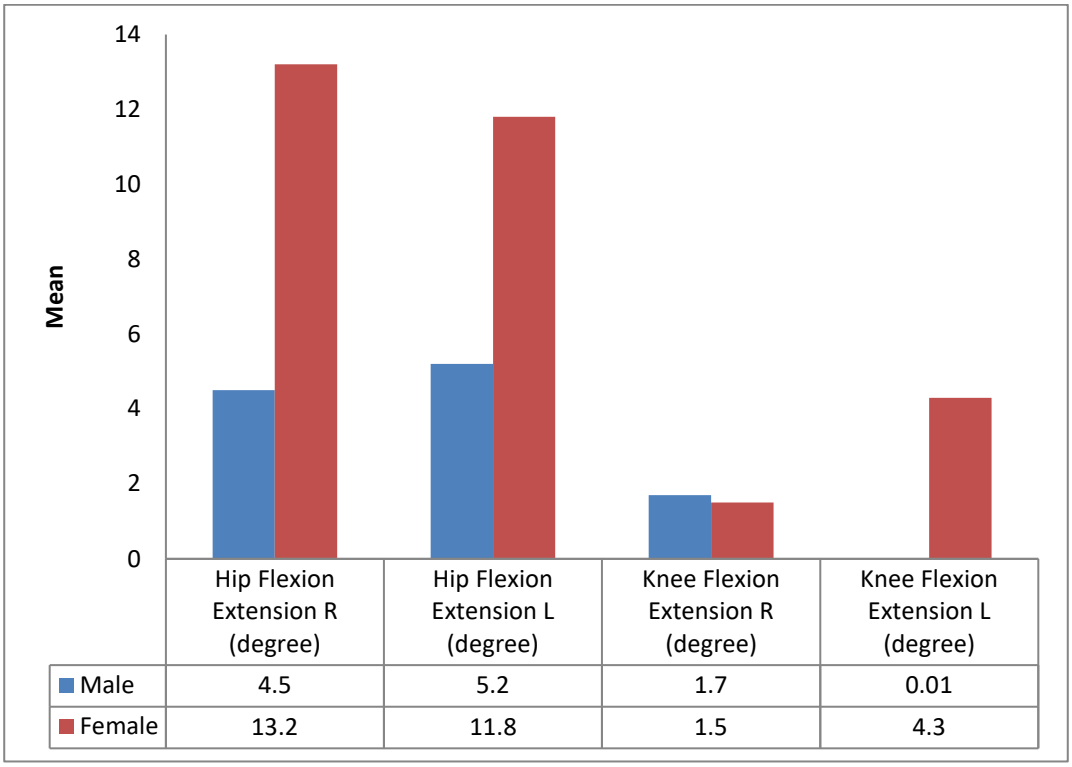
Among the kinematic parameters hip flexion extension degree difference on the right side, among male and female participants was noted as statistically significant with p value of 0.005 whereas the difference in Hip Flexion Extension on left side, Knee Flexion Extension on both the sides was not significant statistically.

Table 35: Kinematic parameter- Hip and Knee flexion and Extension

Parameter	Male	Female	P value
Hip Flexion Extension R (degree)	4.5±8.9	13.2±9.0	0.005*
Hip Flexion Extension L (degree)	5.2±11.2	11.8±10.1	0.073
Knee Flexion Extension R (degree)	1.7±7.8	1.5±8.0	0.209
Knee Flexion Extension L (degree)	0.01±8.6	4.3±10.9	0.170

*Significant

Graph 33: Kinematic parameter- Hip and Knee flexion and Extension



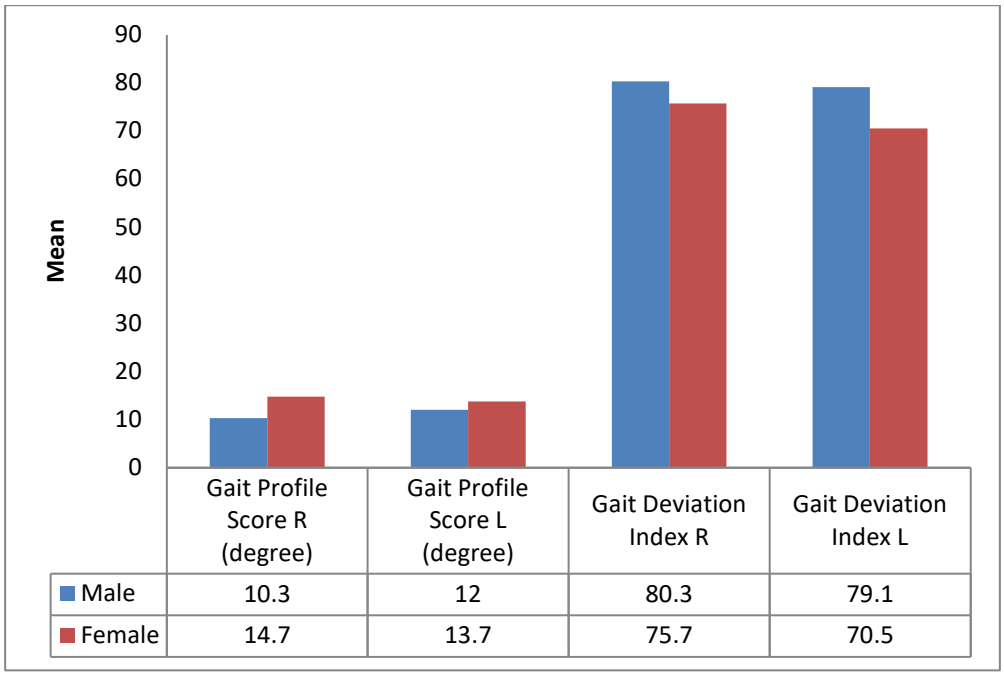
In this study the difference in right side gait profile score between male and female participants was statistically significant (p value =0.022) and the difference in Gait Deviation Index based on gender on the left side was also statistically significant (p value = 0.010).

Table 36: Difference in Gait profile score and gait deviation index based on gender

Parameter	Male	Female	P value
Gait Profile Score R (degree)	10.3±4.2	14.7±7.6	0.022*
Gait Profile Score L (degree)	12.0±5.3	13.7±4.3	0.312
Gait Deviation Index R	80.3±11.3	75.7±11.1	0.211
Gait Deviation Index L	79.1±11.0	70.5±7.2	0.010*

*Significant

Graph 34: Difference in Gait profile score and gait deviation index based on gender



DISCUSSION

In this study to analyze the differences in Gait among knee osteoarthritis patients there were 7.5% of the participants were less than 40 years of age, 40% of the participants were in the age group of 41 -50 years while 25% of the participants were between 51 – 60 years. In the age group of 61 -70 years and above 70 years of age 12.5% and 15% of the participants were present in this study. Among all the participants 62.5% of them were male participants and 37.5% of them were female participants, in this study male participants with osteoarthritis were found to be higher.

In this current study 27.5% of the participants were housewives, 60% of them were employed, and 12.5% of the participants are unemployed. Based on the activity status maximum of 57.5% of the participants had moderate activity while 25% of the participants had severe activity while 17.5% of the participants had mild physical activity. Habit of smoking was found among 35% of the patients whereas 65% of the patients were non- smokers. Alcohol consumption was found among 45% of the study population

In this current study varus deformity was the common one found among 60% of the participants and valgus deformity was seen among 40% of the participants. On assessing the severity of pain 17.5%, 30% and 27.5% of the participants were found with mild, moderate and severe pain respectively, however 25% of the patients with osteoarthritis had no pain in the knee joints. Based on the Kellgren Lawrence scale x ray findings of knee joint 7.5% of the participants were found with grade 0 OA knee, 17.5% participants were in grade 1 OA knee, 25% of the participants had grade 2 OA knee, 32.5% of the participants were found with grade 3 OA knee and 17.5% of the participants had grade 4 OA knee.

Among 62.5% of the participants, family history of OA knee was recorded while in 37.5% of the participants there was no family history of OA knee. In this present study 40% of the patients were known diabetics whereas 60% of the participants were normal. History of trauma to knee was recorded among 42.5% of the participants in this study whereas 57.5% of the study participants had no trauma history to the knee.

Regarding BMI, maximum (45%) of the participants was found tobe overweight while 32% of the participants were noted to be obese and 22.5% of the participants were normal in this study. The mean general health parameter among the study participants was found to be 74.8 ± 12.2, the mean bodily pain was noted to be 38.5 ± 13.8, the mean physical function was 27.4± 15.7 and the mean physical role function was 23.5 ± 10.2. Among the study patients mean mental health was 61.9± 23.5, the mean emotional role function was 54.7 ± 30.2 and the mean vitality was noted to be 50.5 ± 24.7.

A statistically significant association recorded in this study for Stride time with respects to grading of OA knee on the right side leg while the association for Stride time with respects to grading of OA knee on the left leg was not significant statistically. Meanwhile the association between grading of OA and the stance time on the right and left side leg was found to be statistically insignificant.

On assessing the association between swing time and the grading of OA knee, there was no association between the two on both the sides of leg with statistical insignificance. In this study the association between Single Support Phase and the grading of OA knee, there was statistically significant association found between Single Support Phase on the right and left side and grading of OA knee.

An insignificant association found between Double Support Phase and OA knee grading on the right side knee whereas significant statistical association recorded between Double Support Phase and OA knee grading on the left side knee.

In this present study the association between Mean Velocity and the grading of OA knee, there was no statistically significant association found between Mean Velocity on the right side and grading of OA knee however statistically significant association noted on the left side mean velocity and grading of OA knee. Regarding Cadence (steps/min) and OA knee grading there was no significant statistical association in this study.

Based on the stride length on the right and left side, left side alone statistically significant association was found for stride length and OA knee grading. The association between step length and grading of OA knee was noted as statistically significant on both sides. The association between step width and grading of OA knee was noted to be not statistically significant on both right and left side.

In this current study the kinematic parameter hip flexion extension on the right leg is statistically insignificant with OA grading and on the left side also there was no association found for hip flexion extension and OA grading. Based on the Knee Flexion Extension on the right and left side, right side alone had statistically significant association for Knee Flexion Extension and OA knee grading. There was no statistically significant association found between grading of OA knee and Gait Profile Score in the reporting phase on right and left side. Likewise there was no statistically significant association found between grading of OA knee and Gait Deviation Index in the reporting phase on right and left side.

The mean general health among male and female participants was 78.1±11.5 and 71.7±13.4respectively, but the difference between males and females for general health wellbeing was not statistically significant. Likewise there was no statistically significant difference noted between male and female participants for bodily pain, physical function, physical role function, social function, mental health, emotional role and vitality, which shows there was no difference in the general and physical health based on gender for osteoarthritis.

Based on the stride time on the right side knee joints there was no significant statistical difference found between male and female participants whereas the difference in stride time on the left side knee joint among male and female participants was noted to be statistically significant in this study. Regarding the stance time there was no statistically significant difference found between gender on both the right and left side knee. The difference in Swing time on the right and left side knee was also found to be statistically insignificant.

Temporal parameters based on gait analysis like Single Support Phase on the right knee was among the male and female participants was not statistically significant which shows there was no difference in Single Support Phase percentage based on gender whereas the difference in Single Support Phase on the left knee among both the gender was found to be statistically significant. Double Support Phase on the right knee was insignificant with no difference between male and female participants while the difference in Double Support Phase on the left knee between male and female participants were statistically significant.

In this study based on the gait analysis there was statistical significant difference found between males and females for mean velocity and cadence. There

was no significant difference found for spatial parameters like Stride Length, Step lengthand step width between male and female participants of this study on both side knees.

Among the kinematic parameters hip flexion extension degree difference on the right side, among male and female participants was noted as statistically significant whereas the difference in Hip Flexion Extension on left side, Knee Flexion Extension on both the sides was not significant statistically. In this study the difference in right side gait profile score between male and female participants was statistically significant and the difference in Gait Deviation Index based on gender on the left side was also statistically significant.

The findings of this study were comparable with the findings of the following study. Butler RJ et al[52] performed a study and reported that cases with lateral knee osteoarthritis was found to have lower knee adduction excursion, reduced peak knee abduction moment and reduced peak rear-foot eversion compared with the healthy non osteoarthritis knee controls. These differences in the gait parameters among the cases with lateral knee osteoarthritis knee and healthy non osteoarthritis knee controls were found to be statistically significant, in their study. They stated that cases with lateral knee osteoarthritis were found to have frontal-plane gait mechanics at the knee which was found to be significantly different from the cases with medial knee osteoarthritis. These differences in the frontal plane gait mechanics among the cases with lateral knee osteoarthritis knee and medial knee osteoarthritis were found to be statistically significant, in their study. Kiss RM et al[53] found a reduced variability of angular parameters on the side of osteoarthritis knee which represents that there is a reduced joint flexibility. This in turn results in reduced consistency in the movements

of the legs from stride-to-stride, as noted along with high variability of spatial-temporal parameters, in their study. Also they reported that there were a significant reduction in joint flexibility and consistency of movement which was found to be associated with the reduced complexity of movement, in their study.

In another study conducted by Gaudreault N et al[54] reported that they noted an increased quadriceps and hamstring strength following the physiotherapy treatment compared to the pre treatment status, in their study. Also higher first peak flexion moment, reduced adduction moment impulse and smaller rotation angle range were noted after the treatment with physiotherapy, in their study. The mean differences in these parameters before and after the treatment with physiotherapy were found to be statistically significant. Laroche et al[55] reported that spatio - temporal parameters, kinematic joint and trunk angles are the most reliable parameters of 3dimensional gait analysis among the cases with hip osteoarthritis, in their study. They reported that the mean differences in angles measured by 3D gait analysis and angles measured manually using a goniometer were reported to be more similar with a difference of less than one percentage. Zeni JA et al[56] conducted a study and reported that an increase in the ankle contribution and a reduction in the hip contribution while walking speed was increased were noted among the cases with osteoarthritis knee however the same was not reported among the controls. These differences in the gait parameters among the cases with osteoarthritis knee and healthy non osteoarthritis knee controls were found to be statistically significant, in their study. Also reduction in the gait speed was noted among the cases with osteoarthritis knee along with joint pain and muscle weakness, significantly.

However, Baert IAC et al[57] reported that the cases with osteoarthritis were found to have no altered gait pattern, no statistical significant increase in the knee joint loading and no statistical significant decrease in hamstring muscle strength compared to the known cases of osteoarthritis knee, in their study. However, the cases with early osteoarthritis knee were reported to have statistically significant quadriceps weakness compared with the known cases of osteoarthritis knee.

On the study conducted by Turcot K et al[58] reported that the cases with osteoarthritis knee were found to have significantly different gait patterns. Cases with varus knee were found to be significantly correlated with the trunk movements in sagittal and frontal planes when compared with the cases with valgus knee, in their study. Also they stated that the valgus knee cases were found to have lower pain and lower functional deficits compared to the cases with a varus knee. Baudet A et al[61] in their study they reported that the difference in the kinematic profile for knee varus knee or valgus knee and knee flexion or knee extension was found to be lower and higher, respectively, in their study. These differences in the kinematic profile of gait parameters among the cases with varus knee or valgus knee and healthy non osteoarthritis knee controls were found to be statistically significant.

Also, Bytyqi D et al[62] in their study reported that cases with osteoarthritis knee were found to have less extension during the stance phase and less flexion during pushoff and initial swing phase. These differences in the gait parameters among the cases with osteoarthritis knee and healthy non osteoarthritis knee controls were found to be statistically significant, in their study. Also higher adduction angle was reported among the cases with osteoarthritis knee compared to the healthy non osteoarthritis knee controls and the difference was found to be statistically significant.

Tadano S et al[63] conducted a study and reported that the abduction in the ankle joints during stance were reduced in order to avoid adduction at the knee as the severity of osteoarthritis increases and resulting in more acute angles between the right and left knee.

In the study conducted by Phinyomark A et al[64] stated that female cases with osteoarthritis knee and non osteoarthritis knee females were found to have higher knee abduction and hip adduction angles compared to the male cases with osteoarthritis knee and non osteoarthritis knee. These differences in the knee abduction and hip adduction angles among the female cases with and without osteoarthritis knee and male cases with and without osteoarthritis knee were found to be statistically significant, in their study. Also there were no significant differences were reported with respect to any of the discrete gait kinematic parameters between the cases with and without osteoarthritis knee either among the male and female study population. Sparkes V et al[66] performed a study and reported that cases with osteoarthritis was found to have low peak frontal hip and sagittal knee moments, and reduced peak anterior ground reaction force with the affected limb during walking compared to the non osteoarthritis knee controls. These differences in the gait parameters among the cases with osteoarthritis knee and healthy non osteoarthritis knee controls were found to be statistically significant, in their study. Also they stated that the osteoarthritis cases had slower walking cadence and they took longer on timed functional measures, in their study. These differences in the gait cadence and time taken for functional measures among the cases with osteoarthritis knee and healthy non osteoarthritis knee controls were found to be statistically significant.

However, Ismailidis P et al[68] conducted a study to assess the effect of walking speed on kinematic variables among the cases with osteoarthritis knee and reported that at patient's own walking speed, lower knee flexion was noted among the cases with osteoarthritis knee during stance and also during swing. These differences in the gait parameters among the cases with osteoarthritis knee and healthy non osteoarthritis knee controls were found to be statistically significant. The differences in sagittal plane gait kinematics parameters among cases with osteoarthritis knee were mainly reduced the respect to the walking speed of the cases, in their study.

In another study, Pinto RF et al[70] reported that the parameters like frontal and sagittal plane knee angles and moments among the cases with osteoarthritis knee evaluated using a treadmill-based gait analysis system were reported as the valid and reliable markers for the assessment of gait among the cases with osteoarthritis knee, in their study. Schrijvers JC et al[71] conducted a study and reported that there are differences between the findings of the different gait laboratories which could obstruct the exact comparison of gait database among the cases with knee osteoarthritis, in their study. In order to reduce these differences, they suggested harmonization of gait analysis, in the very first step itself. Ismailidis P et al[72] conducted a study and reported that the cases with knee osteoarthritis were found to have reduced walking speed, increased stride duration, lessen stride length and reduced cadence compared to the cases without osteoarthritis knee. These differences in the gait parameters among the cases with osteoarthritis knee and healthy non osteoarthritis knee controls were found to be statistically significant. Peak knee flexion at stance and swing was found to be reduced in the side which was affected with osteoarthritis compared to the unaffected non osteoarthritis side, in their study. Also the differences in the peak knee flexion at stance and swing on the osteoarthritis

knee side and healthy non osteoarthritis knee controls were found to be statistically significant, in their study. Also notably knee range of motion during loading response and swing was found to be reduced in the non osteoarthritis knee group.

Limitation and recommendations

The limitations of this study includes unequal distribution of samples between male and female populations and addition of electromyographic recordings could have given accurate measures of individual muscle weakened thereby helping in understanding the pathomechanics of osteoarthritis. Future studies with more sample size and Multicentric study are recommended

CONCLUSION

In this study to analyze the differences in Gait among knee osteoarthritis majority of the study participants were in the age group of 41 -50 years with male predominance. Varus deformity was noted in 60% of the cases and valgus deformity in 40% of cases. Based on the Kellgren Lawrence scale x ray findings of knee joint 7.5%, 17.5%, 25%, 32.5% and 17.5% of cases were found with grade 0, grade 1, grade 2, grade 3 and grade 4 OA knee, respectively. Also 62.5% of the participants had positive family history of OA knee and history of trauma to knee was recorded among 42.5% of the participants in this study. Based on BMI, 45% and 32% of the participants was found to be overweight and obese, respectively.

On right side, the mean difference in stride time, single support phase, step length, and knee flexion extension were the parameters found to be different with respect grades of osteoarthritis knee. However, the mean difference in stance time, swing time, double support phase, mean velocity, stride length, step width, hip flexion extension, gait profile score and gait deviation index in different grades of osteoarthritis knee was found to be statistically insignificant. Also cadance was found to be similar in all grades of osteoarthritis knee without any statistical significance.

On left side, the mean difference in single support phase, double support phase, mean velocity, stride length and step length were the parameters found to be different with respect grades of osteoarthritis knee. However, the mean difference in stride time, stance time, swing time, step width, hip flexion extension, knee flexion extension, gait profile score and gait deviation index in different grades of osteoarthritis knee was found to be statistically insignificant.

On comparing the general health status, bodily pain, physical function, physical role function, social function, mental health, emotional role function and

vitality among males and females, there was no statistical significant difference reported. However, parameters like stride time, single and double support phase of left side, mean velocity, cadence, hip flexion extension on right side, gait profile core of right and gait deviation index of left side were the parameters which were found to be significantly different among male and female participants.

SUMMARY

Osteoarthritis has impact not only on the involved joint but also affects the other joints and invariably affects the gait of the individual. This study was performed to determine the differences in the gait parameters among cases with history and varying grades of knee osteoarthritis using 3d gait analyzer.

A cross sectional study was conducted in the department of Orthopedics in Jawaharlal Nehru Medical College, Belagavi among the cases with osteoarthritis knee attending outpatient and inpatient department of Orthopedics during January 2020 to December 2020. A total of forty patients with osteoarthritis of knee joint were included in this study. Ethical committee approval was obtained for this study. With bilateral knee X rays and their entire gait parameters were assessed using 3D gait analyzer.

Varus deformity was noted in 60% of the cases and valgus deformity in 40% of cases. Based on the Kellgren Lawrence scale x ray findings of knee joint 7.5%, 17.5%, 25%, 32.5% and 17.5% of cases were found with grade 0, grade 1, grade 2, grade 3 and grade 4 OA knee, respectively. On right side, the mean difference in stride time, single support phase, step length, cadence and knee flexion extension were the parameters found to be significantly different with respect grades of osteoarthritis knee. On left side, the mean difference in single support phase, double support phase, mean velocity, stride length and step length were the parameters found to be different with respect grades of osteoarthritis knee. We conclude 3D gait analyzer can be used in routine for all cases of osteoarthritis not only to assess their gait abnormalities but also to assess the severity of osteoarthritis knee.

BIBLIOGRAPHY

1. Zhang W, Moskowitz RW, Nuki G, Abramson S, Altman RD, Arden N, et al. OARSI recommendations for the management of hip and knee osteoarthritis, Part II:OARSI evidence-based, expert consensus guidelines. Osteoarthritis Cartilage 2008;16:137-62.
2. Vos T, Barber RM, Bell B, Bertozzi-Villa A, Biryukov S, Bolliger I, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 301 acute and chronic diseases and injuries in 188 countries, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. The Lancet 2015;386(9995):743-800.
3. Murphy L, Helmick CG. The impact of osteoarthritis in the United States: a population-health perspective. AJN Am J Nurs 2012;112(3):S13-9.
4. Kurtz S, Ong K, Mowat F, Halpern M. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. JBJS 2007;89(4):780-5.
5. Fitzgerald GK, Piva SR, Irrgang JJ. Reports of joint instability in knee osteoarthritis: its prevalence and relationship to physical function. Arthritis Rheum 2004;51:941e6.
6. Lewek MD, Ramsey DK, Snyder-Mackler L, Rudolph KS. Knee stabilization in patients with medial compartment knee osteoarthritis. Arthritis Rheum 2005;52:2845e53.
7. Schipplein OD, Andriacchi TP. Interaction between active and passive knee stabilizers during level walking. J Orthop Res 1991;9:113e9.
8. Perry J. Gait Analysis: Normal and Pathological Function. Thorofare (NJ): SLACK; 1992.
9. Sharma L, Hurwitz DE, Thonar EJ, et al. 1998. Knee adduction moment, serum hyaluronan level, and disease severity in medial tibiofemoral osteoarthritis. Arthritis Rheum 41:1233–1240.
10. Mundermann A, Dyrby CO, Andriacchi TP. 2005. Secondary gait changes in patients with medial compartment knee osteoarthritis: Increased load at the ankle, knee, and hip during walking. Arthritis Rheum 52:2835–2844.

11. Hannan MT, Felson DT, Pincus T. 2000. Analysis of the discordance between radiographic changes and knee pain in osteoarthritis of the knee. J Rheumatol 27:1513–1517.
12. Dieppe PA. 2005. Relationship between symptoms and structural change in osteoarthritis: what are the important targets for therapy? J Rheumatol 32:1147–1149.
13. Chau T. A review of analytical techniques for gait data. Part 1: fuzzy, statistical and fractal methods. Gait Posture 2001;13(1): 49e66.
14. Gok H, Ergin S, Yavuzer G. Kinetic and kinematic characteristic of gait in patients with medial knee arthrosis. Acta Orthop Scand 2002;73:647–52.
15. Mundermann A, Dyrby CO, Hurwitz DE, Sharma L, Andriacchi TP. Potential strategies to reduce medial compartment loading in patients with knee osteoarthritis of varying severity: reduced walking speed [erratum appears in Arthritis Rheum. 2004 Dec;50 (12):4073]. Arthritis Rheum 2004;50(4):1172–8.
16. Astephen JL, Deluzio KJ. Changes in frontal plane dynamics and the loading response phase of the gait cycle are characteristic of severe knee osteoarthritis application of a multidimensional analysis technique. Clin Biomech 2005;20(2):209–17.
17. Baliunas AJ, Hurwitz DE, Ryals AB, Karrar A, Case JP, Block JA, et al. Increased knee joint loads during walking are present in subjects with knee osteoarthritis. Osteoarthr Cartilage 2002;10(7):573–9.
18. Miyazaki T, Wada M, Kawahara H, Sato M, Baba H, Shimada S. Dynamic load at baseline can predict radiographic disease progression in medial compartment knee osteoarthritis. Ann Theum Dis 2002;61:617–22.
19. Thorp LE, Sumner DR, Block JA, Moisio KC, Shott S, Wimmer MA. Knee joint loading differs in individuals with mild compared with moderate medial knee osteoarthritis. Arthritis Rheum 2006;54(12):3842–9.

20. Maly MR, Costigan PA, Olney SJ. Role of knee kinematics and kinetics on performance and disability in people with medial compartment knee osteoarthritis. Clin Biomech 2006;21(10):1051–9.
21. McGibbon CA, Krebs DE. Compensatory gait mechanics in patients with unilateral knee arthritis. J Rheumatol 2002;29(11):2410–9.
22. Al-Zahrani KS, Bakheit AMO. A study of the gait characteristics of patients with chronic osteoarthritis of the knee. Disabil Rehabil 2002;24(5):275–80.
23. Bejek Z, Paroczai R, Illyes A, Kiss RM. The influence ofwalking speed on gait parameters in healthy people and in patients with osteoarthritis. Knee Surg Sports Traumatol Arthrosc 2006;14(7):612–22.
24. Wilson WA (1989) Estimates of the US prevalence of systemic lupus erythematosus: comment on the article by Lawrence et al. Arthr Rheum 41:778–799
25. Childs JD, Sparto PJ, Fitzgerald GK, Bizzini M, Irrgang JJ (2004) Alterations in lower extremity movement and muscle activation patterns in individuals with knee osteoarthritis. Clin Biomech 19(1):44–49
26. Harrington IJ (1983) Static and dynamic loading patterns in knee joints with deformities. J Bone Joint Surg Am 65:247–259
27. Roos EM, Lohmander LS (2003) The knee injury and osteoarthritis outcome score (KOOS): from joint injury to osteoarthritis. Health Qual Life Outcomes 1:64
28. Zhang Y, Jordan JM. Epidemiology of osteoarthritis. *Rheum Dis Clin North Am.* Aug 2008;34(3):515-529.
29. Eitner A, Hofmann GO, Schaible HG. Mechanisms of osteoarthritic pain. Studies in humans and experimental models. Frontiers in molecular neuroscience. 2017 Nov 3;10:349.
30. Jang S, Lee K, Ju JH. Recent Updates of Diagnosis, Pathophysiology, and Treatment on Osteoarthritis of the Knee. International Journal of Molecular Sciences. 2021 Jan;22(5):2619.

31. Kellgren J, Lawrence J. Radiologic assessment of osteoarthritis. Ann Rheum Dis 1957; 16: 494-501.
32. Parker DA, Scholes C, Neri T. Non-operative treatment options for knee osteoarthritis: current concepts. Journal of ISAKOS: Joint Disorders & Orthopaedic Sports Medicine. 2018 Sep 1;3(5):274-81.
33. Barrett JR et al, Practical tips in the treatment of osteoarthritis of the Knee [online] Practical Pain Management., 2021 Available at: https://www.practicalpainmanagement.com/pain/myofascial/osteoarthritis/practical-tips-treatment-osteoarthritis-knee [Accessed 16 May 2021]
34. Hall M, Bennell KL, Wrigley TV, Metcalf BR, Kasza J, Paterson KL, Hunter DJ, Hinman RS. The knee adduction moment and osteoarthritis symptoms: relationships according to radiographic disease severity. Osteoarthritis and Cartilage. 2016 Apr 1;24:S448-9.
35. Kean CO, Hinman RS, Bowles KA, Cicuttini F, Davies-Tuck M, Bennell KL. Comparison of peak knee adduction moment and knee adduction moment impulse in distinguishing between severities of knee osteoarthritis. Clinical biomechanics. 2012 Jun 1;27(5):520-3.
36. Chang AH, Moisio KC, Chmiel JS, Eckstein F, Guermazi A, Prasad PV, Zhang Y, Almagor O, Belisle L, Hayes K, Sharma L. External knee adduction and flexion moments during gait and medial tibiofemoral disease progression in knee osteoarthritis. Osteoarthritis and cartilage. 2015 Jul 1;23(7):1099-106.
37. Abedin J, Antony J, McGuinness K, Moran K, O'Connor NE, Rebholz-Schuhmann D, Newell J. Predicting knee osteoarthritis severity: Comparative modeling based on patient's data and plain X-ray images. Scientific reports. 2019 Apr 8;9(1):1-1.
38. Kwon SB, Ro DH, Song MK, Han HS, Lee MC, Kim HC. Identifying key gait features associated with the radiological grade of knee osteoarthritis. Osteoarthritis and cartilage. 2019 Dec 1;27(12):1755-60.

39. Al-Zahrani KS, Bakheit AM. A study of the gait characteristics of patients with chronic osteoarthritis of the knee. Disability and rehabilitation. 2002 Jan 1;24(5):275-80.
40. Weidow J, Tranberg R, Saari T, Kärrholm J. Hip and knee joint rotations differ between patients with medial and lateral knee osteoarthritis: gait analysis of 30 patients and 15 controls. Journal of Orthopaedic Research. 2006 Sep;24(9):1890-9.
41. Lewek MD, Scholz J, Rudolph KS, Snyder-Mackler L. Stride-to-stride variability of knee motion in patients with knee osteoarthritis. Gait & posture. 2006 Jun 1;23(4):505-11.
42. Lynn SK, Reid SM, Costigan PA. The influence of gait pattern on signs of knee osteoarthritis in older adults over a 5–11 year follow-up period: a case study analysis. The Knee. 2007 Jan 1;14(1):22-8.
43. Astephen JL, Deluzio KJ, Caldwell GE, Dunbar MJ. Biomechanical changes at the hip, knee, and ankle joints during gait are associated with knee osteoarthritis severity. Journal of orthopaedic research. 2008 Mar;26(3):332-41.
44. Van Der Esch M, Steultjens M, Harlaar J, Wolterbeek N, Knol DL, Dekker J. Knee varus–valgus motion during gait–a measure of joint stability in patients with osteoarthritis?. Osteoarthritis and cartilage. 2008 Apr 1;16(4):522-5.
45. Lynn SK, Costigan PA. Effect of foot rotation on knee kinetics and hamstring activation in older adults with and without signs of knee osteoarthritis. Clinical Biomechanics. 2008 Jul 1;23(6):779-86.
46. Huang SC, Wei IP, Chien HL, Wang TM, Liu YH, Chen HL, Lu TW, Lin JG. Effects of severity of degeneration on gait patterns in patients with medial knee osteoarthritis. Medical engineering & physics. 2008 Oct 1;30(8):997-1003.
47. Heiden TL, Lloyd DG, Ackland TR. Knee joint kinematics, kinetics and muscle co-contraction in knee osteoarthritis patient gait. Clinical biomechanics. 2009 Dec 1;24(10):833-41.

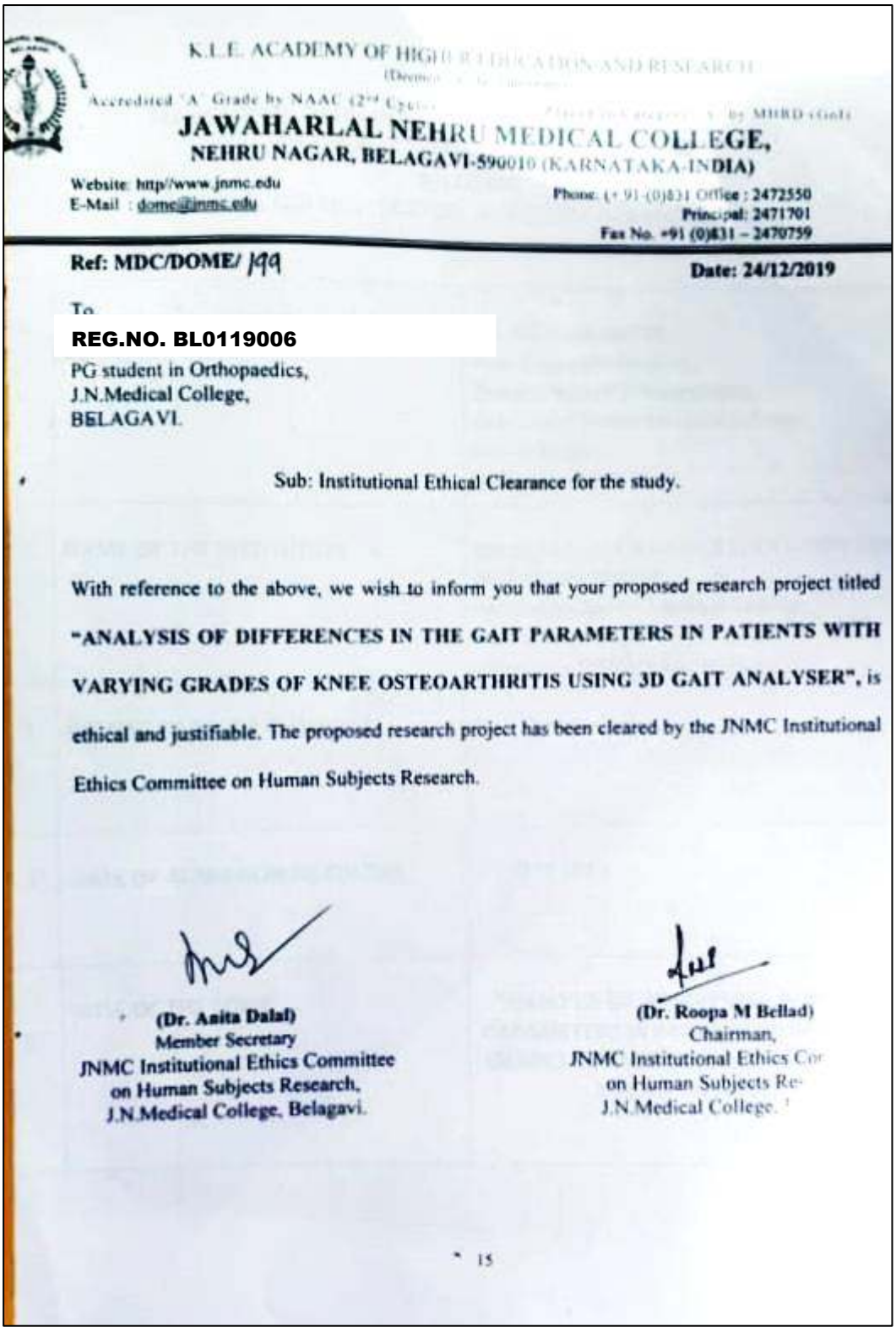
48. Zeni Jr JA, Higginson JS. Differences in gait parameters between healthy subjects and persons with moderate and severe knee osteoarthritis: a result of altered walking speed?. Clinical biomechanics. 2009 May 1;24(4):372-8.
49. Richards C, Higginson JS. Knee contact force in subjects with symmetrical OA grades: differences between OA severities. Journal of biomechanics. 2010 Sep 17;43(13):2595-600.
50. Ornetti P, Maillefert JF, Laroche D, Morisset C, Dougados M, Gossec L. Gait analysis as a quantifiable outcome measure in hip or knee osteoarthritis: a systematic review. Joint Bone Spine. 2010 Oct 1;77(5):421-5.
51. Yakhdani HR, Bafghi HA, Meijer OG, Bruijn SM, van den Dikkenberg N, Stibbe AB, van Royen BJ, van Dieën JH. Stability and variability of knee kinematics during gait in knee osteoarthritis before and after replacement surgery. Clinical biomechanics. 2010 Mar 1;25(3):230-6.
52. Butler RJ, Barrios JA, Royer T, Davis IS. Frontal-plane gait mechanics in people with medial knee osteoarthritis are different from those in people with lateral knee osteoarthritis. Physical therapy. 2011 Aug 1;91(8):1235-43.
53. Kiss RM. Effect of severity of knee osteoarthritis on the variability of gait parameters. Journal of Electromyography and Kinesiology. 2011 Oct 1;21(5):695-703.
54. Gaudreault N, Mezghani N, Turcot K, Hagemeister N, Boivin K, De Guise JA. Effects of physiotherapy treatment on knee osteoarthritis gait data using principal component analysis. Clinical Biomechanics. 2011 Mar 1;26(3):284-91.
55. Laroche D, Duval A, Morisset C, Beis JN, d'Athis P, Maillefert JF, Ornetti P. Test–retest reliability of 3D kinematic gait variables in hip osteoarthritis patients. Osteoarthritis and cartilage. 2011 Feb 1;19(2):194-9.
56. Zeni JA, Higginson JS. Knee osteoarthritis affects the distribution of joint moments during gait. The Knee. 2011 Jun 1;18(3):156-9.

57. Baert IA, Jonkers I, Staes F, Luyten FP, Truijen S, Verschueren SM. Gait characteristics and lower limb muscle strength in women with early and established knee osteoarthritis. Clinical biomechanics. 2013 Jan 1;28(1):40-7.
58. Turcot K, Armand S, Lübbeke A, Fritschy D, Hoffmeyer P, Suvà D. Does knee alignment influence gait in patients with severe knee osteoarthritis?. Clinical biomechanics. 2013 Jan 1;28(1):34-9.
59. Sagawa Jr Y, Armand S, Lubbeke A, Hoffmeyer P, Fritschy D, Suva D, Turcot K. Associations between gait and clinical parameters in patients with severe knee osteoarthritis: A multiple correspondence analysis. Clinical biomechanics. 2013 Mar 1;28(3):299-305.
60. Esrafilian A, Karimi MT, Amiri P, Fatoye F. Performance of subjects with knee osteoarthritis during walking: differential parameters. Rheumatology international. 2013 Jul 1;33(7):1753-61.
61. Baudet A, Morisset C, d'Athis P, Maillefert JF, Casillas JM, Ornetti P, Laroche D. Cross-talk correction method for knee kinematics in gait analysis using principal component analysis (PCA): a new proposal. PloS one. 2014 Jul 8;9(7):e102098.
62. Bytyqi D, Shabani B, Lustig S, Cheze L, Gjurgjeala NK, Neyret P. Gait knee kinematic alterations in medial osteoarthritis: three dimensional assessment. International orthopaedics. 2014 Jun;38(6):1191-8.
63. Tadano S, Takeda R, Sasaki K, Fujisawa T, Tohyama H. Gait characterization for osteoarthritis patients using wearable gait sensors (H-Gait systems). Journal of biomechanics. 2016 Mar 21;49(5):684-90.
64. Phinyomark A, Osis ST, Hettinga BA, Kobsar D, Ferber R. Gender differences in gait kinematics for patients with knee osteoarthritis. BMC musculoskeletal disorders. 2016 Dec;17(1):1-2.
65. Kwon SB, Ro DH, Song MK, Han HS, Lee MC, Kim HC. Identifying key gait features associated with the radiological grade of knee osteoarthritis. Osteoarthritis and cartilage. 2019 Dec 1;27(12):1755-60.

66. Sparkes V, Whatling GM, Biggs P, Khatib N, Al-Amri M, Williams D, Hemming R, Hagen M, Saleem I, Swaminathan R, Holt C. Comparison of gait, functional activities, and patient-reported outcome measures in patients with knee osteoarthritis and healthy adults using 3D motion analysis and activity monitoring: an exploratory case-control analysis. Orthopedic research and reviews. 2019;11:129.
67. Pacifico D, Visscher R, List R, Item-Glatthorn JF, Casartelli NC, Maffiuletti NA. Discriminant validity and reproducibility of spatiotemporal and kinetic parameters during treadmill walking in patients with knee osteoarthritis. Gait & Posture. 2020 Jul 1;80:77-9.
68. Ismailidis P, Egloff C, Hegglin L, Pagenstert G, Kernen R, Eckardt A, Ilchmann T, Mündermann A, Nüesch C. Kinematic changes in patients with severe knee osteoarthritis are a result of reduced walking speed rather than disease severity. Gait & Posture. 2020 Jun 1;79:256-61.
69. Kwon SB, Han HS, Lee MC, Kim HC, Ku Y. Machine learning-based automatic classification of knee osteoarthritis severity using gait data and radiographic images. IEEE Access. 2020 Jul 1;8:120597-603.
70. Pinto RF, Birmingham TB, Leitch KM, Atkinson HF, Jones IC, Giffin JR. Reliability and validity of knee angles and moments in patients with osteoarthritis using a treadmill-based gait analysis system. Gait & Posture. 2020 Jul 1;80:155-61.
71. Schrijvers JC, Rutherford D, Richards R, van den Noort JC, van der Esch M, Harlaar J. Inter-laboratory comparison of knee biomechanics and muscle activation patterns during gait in patients with knee osteoarthritis. The Knee. 2021 Mar 1;29:500-9.
72. Ismailidis P, Hegglin L, Egloff C, Pagenstert G, Kernen R, Eckardt A, Ilchmann T, Nüesch C, Mündermann A. Side to side kinematic gait differences within patients and spatiotemporal and kinematic gait differences between patients with severe knee osteoarthritis and controls measured with inertial sensors. Gait & Posture. 2021 Feb 1;84:24-30.

73. Jayalath JLR, Dassanayake TDMSB, Dissanayake MM. Gait variation in patients with knee osteoarthritis: A controlled study. Int J Physiother Res 2014; 2:677-80.
74. Huang SC, Wei IP, Chien HL, et al. Effects of severity of degeneration on gait patterns in patients with medial knee osteoarthritis. Med Eng Phys 2008; 30:997-1003.
75. Hawker GA, Mian S, Kendzerska T, French M. Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). Arthritis Care Res, 2011; 63: S240-S252.

ANNEXURE I. ETHICAL CLEARANCE.



K.L.E. ACADEMY OF HIGHER EDUCATION AND RESEARCH
(Deemed-to-be-University)
Accredited 'A' Grade by NAAC (2nd Cycle) Placed in Category 'A' by MHRD (GoI)

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Ref: MDC/DOME/ 199 **Date: 24/12/2019**

To

REG.NO. BL0119006

PG student in Orthopaedics,
J.N.Medical College,
BELAGAVI.

Sub: Institutional Ethical Clearance for the study.

With reference to the above, we wish to inform you that your proposed research project titled **"ANALYSIS OF DIFFERENCES IN THE GAIT PARAMETERS IN PATIENTS WITH VARYING GRADES OF KNEE OSTEOARTHRITIS USING 3D GAIT ANALYSER"**, is ethical and justifiable. The proposed research project has been cleared by the JNMC Institutional Ethics Committee on Human Subjects Research.

(Dr. Anita Dalal)
Member Secretary
JNMC Institutional Ethics Committee
on Human Subjects Research,
J.N.Medical College, Belagavi.

(Dr. Roopa M Bellad)
Chairman,
JNMC Institutional Ethics Co
on Human Subjects Re
J.N.Medical College.

15

ANNEXURE II

INFORMED CONSENT

TITLE OF THE STUDY: "ANALYSIS OF DIFFERENCES IN THE GAIT PARAMETERS IN PATIENTS WITH VARYING GRADES OF KNEE OSTEOARTHRITIS USING 3D GAIT ANALYSER"

PRINCIPAL INVESTIGATOR: **REG.NO. BL0119006**

GUIDE: Dr. _____

INTRODUCTION AND PURPOSE

Osteoarthritis of the knee is a degenerative disorder which causes significant morbidity in patients, it has multifactorial etiology affecting both rich and poor population with potentially no cure and drastically affecting the quality of living. Degenerative arthritis has shown a raising trend and contributes to major chunk of chronic orthopedic patients presenting with pain and inability to carry out daily activities. The gait parameters vary according to the severity of disease and understanding this is crucial to initialize educational and treatment modalities to slow down the progression and hence forth to improve quality of living.

The purpose of this study is to determine the alterations in various gait parameters in patients WITH VARYING GRADES OF KNEE OSTEOARTHRITIS USING 3D GAIT ANALYSER and to understand the biomechanics of affected knee there by targeting physiotherapy to aid in affected component and thereby improving the quality of living and delaying the progression of knee osteoarthritis in Orthopaedic department of KLE'S Dr. Prabhakar Kore Hospital and Medical Research Centre and Charitable Hospital, Belagavi from 1st January 2019 to 31st December 2019.

PROCEDURE

If you consent to be in this study, the relevant data is collected as per the proforma, and the final diagnosis is confirmed by taking x rays of the affected knee joints and gait analysis will be done by BTS SMART GAIT ANALYSER BY FOLLOWING SIMPLE HALEN HAYES PROTOCOL.

COMPENSATION

As the subject voluntarily consents to be a part of the study, no compensation will be given.

COMPLICATION: NIL

COSTS OF PARTICIPATIO

The cost of investigations namely X-Ray (Rs. 600) and Gait Analysis (Rs. 2500) will be borne by the participant.

CONFIDENTIALITY

All information collected about the subject during the course of the study will be kept confidential to the extent permitted by the law. The code numbers will identify the subject in this research record. Information from this study may be presented but the subjects identify will be confidential in any publication.

VOLUNTARY PARTICIPATION / WITHDRAWAL

Taking part in this study is voluntary. I may choose not to take part in this study, or if I decide to take part, I can later change my mind and withdraw from the study. My decision will not change the present or future health care or other services that I receive. The investigator or the sponsor may stop my participation in this study.

I will tell of any important new findings that may change my willingness to continue to take part. If I choose not to take part in the study, I will receive the standard treatment for patients with my condition.

If any enquiries in the future or in case of study related injury or illness, you may contact following person:

REG.NO. BL0119006
Post-graduate resident,
Department of Orthopaedics,
J.N. Medical College,
K.A.H.E.R, Belgaum 10

Dr. _____
Associate professor
Department of Orthopaedics,
J.N. Medical College,
K.A.H.E.R, Belgaum 10.

If any enquiries in the future or in case of study related injury or illness, you may contact following person:

DR. ROOPA BELLAD
Chairperson,
Ethical Committee for Human Subject Research,
Associate professor,
Department of Pediatrics,
Jawaharlal Nehru Medical College,
Belagavi- 590010.

ANNEXURE III

PROFORMA

"ANALYSIS OF DIFFERENCES IN THE GAIT PARAMETERS IN PATIENTS WITH VARYING GRADES OF KNEE OSTEOARTHRITIS USING 3D GAIT ANALYSER"

PATIENT NO. IP NO.

I. Socio-demographic data

Name:	
Age:	
Gender:	Male: ( ) Female: ( )
Occupation:	
Activity:	Mild: ( ) Moderate: ( ) Heavy: ( )
Smoking status:	Yes ( ) No ( )
Drinking alcohol:3	Yes ( ) No ( )

II. Clinical presentation:

Deformity	Varus ( ) Valgus ( )
Pain according to VAS	No pain ( ) 0-4 mm Mild pain ( ) 5-44 mm Moderate pain ( ) 45-74 mm Severe pain ( ) 75-100 mm
Grading according to X-Ray (Kellgren Lawrence scale)	Grade 0 ( ) Grade 1 ( ) Grade 2 ( ) Grade 3 ( ) Grade 4 ( )

III. Medical morbidity:

History of OA in family	Yes ( )	No ( )
Diabetes	Yes ( )	No ( )
Associated trauma	Yes ( )	No ( )
Body Mass index (kg/m2):		
Height (cm)		
Weight (kg)		

Gait parameters to be evaluated by BTS SMART GAIT ANALYSER BY FOLLOWING SIMPLE HALEN HAYES PROTOCOL.

A) Temporal parameters [12][14]

1. Stride time (sec)
2. Stance time (sec)
3. Swing time (sec)
4. Single support phase (%)
5. Double support phase (%)
6. Mean velocity (m/s)
7. Mean velocity (%height):
8. Cadence (steps/min)

B) Spatial parameters [4]

1. Stride length (m)
2. Step length (m)
3. Step width (m)

C) Kinematic parameters [4][2][1]

1. Hip Flexion - Extension (degree)
2. Knee Flexion - Extension (degree)
3. Knee Valgus - Varus (degree)
4. Knee rotation (degree)

D) Kinetic parameters [4]

1. Knee Movement (N*m/kg)
2. Knee power (Wt/kg)

E) Ground Reaction Force [4]

1. Vertical Force (% body weight)

ANNEXURE IV

PHOTOGRAPHS

Photograph 1. Gait lab

Photograph 2. Subject Walking On Pressure Sensor Foot Plates

Photograph 3. Infrared sensitive probes placed on landmarks

Photograph 3. Infrared sensitive probes placed on landmarks on the back

ANNEXURE V - KEY TO MASTERCHART

Gender : 1-male, 2-female

Occupation : 1-housewife, 2- employed, 3-unemployed

Activity : 1-mild, 2-moderate, 3-heavy

Smoking, alcohol, H/o OA in family, Diabetes, ass trauma: 1-yes, 2-no

Deformity : 1-varus, 2-valgus

Pain : -no pain, 2-mild, 3-moderate, 4-severe

Master Chart

sl no	Age	gender	occ	activity	smoking	alcohol	Deformity	Pain	X ray grading	H/o OfA in amily	Diabetes	ass trauma	Height	Weight	GH1	2	LA1	2	3	4	5	6	7	8	9
1	69	2	1	1	2	1	1	4	4	1	1	1	150	50.3	4	3	2	1	2	2	1	2	2	1	2
2	54	1	3	3	1	2	1	3	3	2	2	2	178	53	3	4	2	2	2	2	2	1	2	1	2
3	66	1	2	1	1	1	1	4	4	1	1	1	168	63	3	3	1	1	1	1	1	1	1	1	1
4	59	2	1	2	2	2	1	3	3	1	1	1	152	54.8	4	3	1	2	1	1	1	2	1	1	1
5	51	1	2	2	1	1	1	2	2	2	2	2	173	84.9	3	3	2	2	2	2	2	2	3	3	3
6	72	1	2	2	1	2	1	3	3	1	2	2	167	54.2	2	3	2	1	2	2	1	1	1	1	2
7	57	1	2	2	1	1	1	4	3	1	2	2	181	74.8	2	1	2	2	2	2	2	2	2	2	2
8	26	1	2	3	1	1	2	1	0	2	1	1	187	64.1	1	2	2	3	2	2	1	2	2	1	2
9	37	1	2	2	1	1	2	1	1	1	2	2	164	71.4	1	1	3	3	3	3	3	3	3	3	3
10	52	1	2	2	1	1	2	4	4	1	1	2	159	62.8	3	5	1	1	1	1	1	1	1	1	1
11	44	2	1	3	2	2	1	3	2	1	2	2	161	58.1	2	5	2	2	2	2	2	2	2	2	2
12	48	2	1	2	2	2	1	4	3	1	2	1	153	59.7	4	3	2	2	2	2	1	1	1	1	1
13	50	2	2	2	2	2	1	3	2	2	2	2	173	64.8	2	3	2	2	2	2	2	1	1	2	2
14	45	2	1	1	2	2	1	1	1	1	2	1	175	63.7	2	1	2	3	3	1	2	3	2	2	3
15	50	2	3	2	2	2	2	1	1	2	1	2	187	71.5	2	2	3	2	1	2	2	2	3	1	1
16	72	1	2	3	1	2	2	2	2	1	2	1	157	43	4	3	1	2	2	2	2	3	1	1	1
17	72	1	3	2	1	1	1	1	1	2	1	2	156	45.9	3	4	2	2	2	2	2	2	3	3	3
18	72	1	3	1	1	1	1	4	4	1	2	1	163	75.6	3	4	1	1	1	1	1	1	1	1	1
19	50	2	1	3	2	2	2	2	2	2	2	1	187	68	3	3	2	2	2	2	1	3	3	3	3
20	70	2	1	2	2	2	1	3	3	2	2	2	156	66.6	3	4	2	2	2	2	1	2	2	3	3
21	75	1	2	2	1	1	1	4	3	1	1	2	171	59.3	3	4	2	2	3	1	1	1	1	1	2

22	37	1	2	1	2	1	1	3	4	1	2	1	154	50.3	3	1	1	1	3	2	3	2	2	1	2
23	52	1	2	3	1	1	2	2	3	2	1	2	175	53	4	3	2	2	1	2	2	1	2	2	2
24	44	1	2	1	1	1	1	3	2	1	1	2	164	63	3	4	3	2	2	1	3	2	1	1	2
25	48	1	2	2	2	2	2	4	3	1	2	1	146	55.1	2	3	2	2	1	2	1	2	1	3	3
26	50	1	2	2	1	2	2	1	3	2	2	2	158	67.2	2	5	2	2	2	1	1	3	3	1	1
27	45	1	2	2	1	2	1	1	0	1	2	1	147	54	1	3	1	3	2	3	3	1	1	2	2
28	50	2	1	2	1	2	1	4	1	1	1	2	168	9	1	5	3	1	2	1	1	2	2	1	2
29	52	2	1	3	1	2	2	3	4	1	1	1	175	48.9	3	2	2	2	2	2	2	2	2	2	3
30	44	2	2	2	1	2	2	4	2	1	2	2	172	57.2	2	3	2	2	2	1	2	1	3	2	1
31	48	1	1	3	2	1	1	3	3	2	2	1	160	74.8	2	1	3	2	2	2	3	1	2	1	1
32	50	1	3	2	2	2	1	1	2	1	2	2	161	64.1	4	3	1	1	3	2	1	2	2	1	3
33	45	1	2	2	2	1	2	2	1	1	1	2	153	71.4	3	4	2	2	1	2	2	2	3	1	1
34	50	2	1	3	2	2	2	4	0	1	2	1	173	76.1	3	5	1	1	2	2	1	1	1	3	3
35	54	1	2	2	2	1	2	1	2	2	1	2	175	59.7	3	5	3	2	2	2	2	2	2	1	3
36	66	1	2	2	1	1	1	2	4	2	2	2	187	64.1	2	3	2	2	2	3	1	2	1	3	2
37	59	2	2	1	1	2	1	3	2	1	2	2	157	43	4	3	1	1	2	1	1	3	1	3	3
38	51	1	2	2	1	2	1	1	3	2	2	1	156	45.9	2	2	2	2	3	2	2	1	2	1	2
39	72	1	2	3	2	1	2	2	1	1	1	2	163	75.6	1	4	1	1	1	1	1	2	1	3	1
40	70	2	2	2	2	2	2	3	3	2	1	1	187	68	3	4	3	2	2	1	2	1	3	1	2

sl no	EE1	2	3	4	5	GH1	2	3	4	Stride time (S)		Stance time(S)		Swing time(S)		single support phase(%)		Double support phase (%)		Mean velocity (m/s)	mean velocity (%height/ s)	Cadence (Steps/ min)
										R	L	R	L	R	L	R	L	R	L			
1	4	5	4	4	5	2	2	3	2	1.71	1.73	1.09	1.08	0.57	0.61	35.62	33.27	17.84	10.06	0.5	31.58	69.9
2	4	4	4	4	4	2	2	3	2	1.37	1.39	0.89	0.94	0.48	0.44	32.37	34.4	15.9	17.71	0.5	37.11	87.3
3	3	6	4	2	4	3	3	3	3	0.11	1.05	0.64	0.67	0.42	0.38	35.68	39.26	11.55	12.7	1	59.29	113.1
4	6	4	4	2	4	3	3	3	3	1.21	1.24	0.8	0.78	0.42	0.43	35.66	33.56	14.99	14.34	0.7	43.52	97.8
5	2	3	4	4	4	3	3	2	4	1.3	1.33	0.86	0.86	0.45	0.47	35.94	33.78	17.14	13.59	0.8	43.73	91.4
6	4	2	6	4	4	3	2	3	3	1.38	1.4	0.97	0.95	0.4	0.43	31.05	28.63	20.09	18.49	0.5	28.98	86.1
7	2	4	5	2	4	1	1	4	1	1.09	1.14	0.66	0.66	0.44	0.45	41.75	38.22	13.49	5.94	1	57.56	107.7
8	4	6	4	5	3	2	3	4	3	1.16	1.15	0.74	0.75	0.42	0.4	34.48	36.47	15.17	13.5	1	54	103.8
9	1	1	6	5	1	3	3	3	3	1.12	1.12	0.69	0.54	0.41	0.42	37.35	36.6	19.78	12.22	1.2	63.43	107.4
10	4	5	4	3	6	3	3	3	3	1.18	1.16	0.69	0.73	0.5	0.43	36.07	42.66	10.58	10.2	1.1	61.13	102
11	5	5	6	5	6	2	3	3	3	3.28	3.15	2.82	2.68	0.5	0.53	16.36	16.05	55.88	38.19	0.2	10.32	38.1
12	5	3	4	4	4	2	2	3	3	1.23	1.24	0.77	0.76	0.47	0.48	38.83	37.77	12.41	11.41	0.8	53.85	97.2
13	4	2	4	4	4	3	3	3	2	3.28	3.15	2.82	2.68	0.5	0.53	16.36	16.05	55.88	38.19	0.2	10.32	38.1
14	3	5	3	3	3	2	2	3	2	1.26	1.27	0.81	0.79	0.45	0.48	38.37	35.85	13.12	12.91	0.8	52.24	94.8
15	2	4	6	4	4	3	2	3	3	1.11	1.11	0.7	0.71	0.4	0.4	35.89	35.9	15.46	12.82	0.9	57.82	108.6
16	2	6	5	2	2	3	3	3	2	1.74	1.75	1.33	1.36	0.4	0.39	22.57	23	32.85	21.9	0.2	15.12	68.7
17	4	4	4	4	2	2	2	3	3	1.1	1.1	0.67	0.66	0.43	0.43	39.61	39.13	10.32	10.73	1	58.15	109.4
18	6	6	5	2	4	3	3	3	3	1.29	1.3	0.83	0.85	0.47	0.44	34.33	36.07	14.6	15	0.7	42.65	92.4
19	4	4	4	4	6	3	3	3	4	2.32	1.99	1.99	1.7	0.2	0.25	11.02	10.05	33.69	38.44	0.2	10.38	55.8
20	6	6	6	6	6	3	3	3	3	1.43	1.43	0.93	0.91	0.5	0.51	35.86	34.86	15.14	14.53	0.6	39.81	84.3
21	5	5	5	3	4	3	3	3	4	1.69	1.63	1.18	1.04	0.52	0.67	39.58	32.08	14.39	17.71	0.5	28.68	72.2
22	5	5	4	3	4	1	3	3	4	1.1	1.39	0.66	0.73	0.57	0.61	32.37	34.4	19.78	12.7	0.5	31.58	69.9

23	4	4	4	5	3	3	2	3	3	1.29	1.05	0.74	2.68	0.48	0.44	35.68	39.26	15.9	13.59	1	37.11	87.3
24	5	6	4	4	1	2	3	4	2	2.32	1.24	0.69	0.76	0.42	0.38	35.66	33.56	11.55	18.49	1	59.29	113.1
25	3	4	6	4	6	1	2	3	3	1.12	1.33	0.69	2.68	0.42	0.43	35.94	33.78	14.99	5.94	1.2	54	97.8
26	6	6	5	5	6	3	3	3	4	1.18	1.4	2.82	0.79	0.45	0.47	38.37	28.63	17.14	13.5	1.1	63.43	91.4
27	4	4	4	4	4	3	3	3	3	3.28	1.16	0.77	0.71	0.4	0.43	35.89	38.22	20.09	12.22	0.2	61.13	86.1
28	5	4	6	3	4	3	2	2	3	1.23	3.15	2.82	1.36	0.47	0.43	22.57	36.47	13.49	10.2	0.8	10.32	94.8
29	3	3	4	4	3	3	1	3	3	1.09	1.24	0.7	0.66	0.2	0.45	39.61	37.77	15.17	38.19	0.2	31.58	108.6
30	4	6	3	4	5	3	3	4	4	1.16	3.15	1.33	0.85	0.43	0.4	34.33	16.05	19.78	38.44	0.8	37.11	68.7
31	4	3	4	2	4	1	2	4	3	1.12	1.27	0.67	1.7	0.42	0.42	35.66	35.85	19.78	17.71	0.6	59.29	109.4
32	3	2	2	5	4	2	1	3	1	1.18	1.11	0.83	0.91	0.45	0.43	35.94	35.9	10.58	12.7	0.5	10.32	92.4
33	6	3	5	5	4	3	3	3	3	3.28	1.3	1.99	1.04	0.4	0.53	31.05	36.07	55.88	17.71	0.5	52.24	55.8
34	2	4	4	3	4	3	3	3	3	1.23	1.99	0.93	0.94	0.44	0.48	38.83	42.66	12.41	12.7	1	57.82	91.4
35	4	2	3	5	4	2	3	3	3	3.28	1.43	1.18	0.67	0.42	0.53	16.36	16.05	15.46	14.34	0.7	15.12	86.1
36	2	1	5	4	4	2	3	3	3	1.26	1.63	0.89	0.78	0.42	0.48	38.37	37.77	32.85	13.59	0.8	58.15	107.7
37	4	5	4	4	3	3	2	3	3	1.11	1.39	0.64	0.86	0.41	0.4	35.89	16.05	10.32	18.49	0.5	42.65	103.8
38	1	6	3	3	6	2	3	3	4	1.74	1.73	0.8	0.95	0.5	0.39	22.57	35.85	14.6	5.94	1	10.38	107.4
39	4	3	5	4	3	3	2	4	3	1.11	1.39	0.86	0.66	0.5	0.43	39.61	35.9	33.69	17.71	1	39.81	102
40	5	3	4	2	5	2	2	3	3	1.74	1.05	0.97	0.66	0.47	0.51	34.33	23	15.14	12.7	0.5	28.68	38.1

sl no	Stride length(m)		Step length(m)		Step width (m)		Hip Fex-Extension (degree)		Knee Flex extension (degree)		Gait profile score (deg)		Gait deviation index	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L
1	0.8	0.82	0.41	0.4	0.11	0.11	13.4	3.8	15.5	3.9	11.7	14.1	67.8	65.7
2	0.8	0.81	0.42	0.38	0.15	0.15	-16	-18	-3.5	-16	21.5	13	58	74.6
3	1.05	1.07	0.59	0.48	0.11	0.11	0.3	-2.1	-0.7	-8.2	7.1	7.1	84.9	85.7
4	0.9	0.95	0.47	0.45	0.11	0.11	9.6	11.8	10.8	13.3	8.9	12.1	77.4	72.5
5	1.09	1.01	0.55	0.46	0.16	0.16	0.6	4.8	-2.1	3.9	7.1	7.1	94.5	94.6
6	0.66	0.68	0.37	0.31	0.15	0.15	18	15.5	12.9	7.2	8	6.1	85.4	95.9
7	1.25	0.72	0.32	0.33	0.33	0.33	0	0.4	-4.3	-4.7	8.7	5.9	80.3	106
8	1.17	1.15	0.6	0.57	0.15	0.15	9.3	12.7	-10	-7.5	8.3	8.8	89	83.5
9	1.38	1.3	0.73	0.65	0.13	0.13	8.9	8.9	-8.5	-8.3	11	6.6	80.4	90.5
10	1.33	1.27	0.68	0.59	0.17	0.17	6	4.8	4	-6.1	6.2	8.1	93.3	84
11	0.5	0.47	0.23	0.25	0.14	0.14	26.3	27.8	3.8	9.9	13.8	12.8	64.5	68.9
12	1.06	1.03	0.54	0.5	0.11	0.11	8.4	3.2	-1.6	-9.5	21.3	19.1	83.2	73
13	0.5	0.47	0.23	0.25	0.14	0.14	26.3	27.8	3.8	9.9	13.8	12.8	64.5	68.9
14	1.08	1.1	0.54	0.55	0.12	0.12	8.4	4.3	-9.2	-16	12.8	12.6	73.9	75.3
15	1.05	0.94	0.54	0.44	0.12	0.12	12.9	20.5	-7.3	11.3	30.8	25.4	53.3	61.6
16	0.55	0.55	0.24	0.31	0.15	0.15	-0.2	-5.6	5.4	-1.4	16.9	13.8	67.8	69.2
17	1.19	1.17	0.62	0.57	0.09	0.09	-5.3	-7.9	1.3	-6	8.9	10.3	75.7	73.1
18	0.9	0.9	0.44	0.46	0.06	0.06	11.3	10	11.5	2.2	7.3	7.6	92.3	90.8
19	0.33	0.36	0.17	0.18	0.23	0.23	9.2	7.1	-6.3	-6.8	16.8	18.1	67.4	64.3

20	0.88	0.89	0.47	0.43	0.11	0.11	11.8	19.3	7.3	4.2	11	11.1	74.6	74.3
21	0.83	0.8	0.38	0.43	0.14	0.14	-1.3	3.6	3.3	9.7	10.9	10.9	83	65.7
22	0.55	1.3	0.54	0.31	0.14	0.14	9.6	15.5	15.5	9.9	8.7	14.1	93.3	74.6
23	1.19	1.27	0.23	0.33	0.12	0.12	0.6	0.4	-3.5	-9.5	8.3	13	64.5	85.7
24	0.9	0.47	0.54	0.57	0.12	0.12	18	12.7	-0.7	9.9	11	7.1	83.2	72.5
25	0.33	1.03	0.54	0.65	0.15	0.15	0	8.9	10.8	-16	6.2	12.1	64.5	61.6
26	0.88	0.47	0.24	0.57	0.09	0.09	9.3	4.8	-2.1	11.3	13.8	12.6	58	69.2
27	0.83	1.1	0.62	0.65	0.06	0.06	8.9	27.8	12.9	-1.4	12.8	25.4	84.9	73.1
28	1.19	0.94	0.41	0.59	0.23	0.23	6	3.2	-4.3	-6	30.8	13.8	77.4	90.8
29	0.9	0.9	0.42	0.33	0.11	0.11	26.3	27.8	-10	2.2	16.9	10.3	94.5	64.3
30	0.33	0.36	0.59	0.18	0.14	0.14	13.4	4.3	-8.5	13.3	8.9	7.6	85.4	74.3
31	1.05	0.89	0.47	0.43	0.15	0.15	-16	3.8	12.9	3.9	11.7	18.1	84.9	65.7
32	0.9	0.81	0.47	0.31	0.33	0.33	0.3	-18	-4.3	7.2	21.5	11.1	77.4	74.6
33	1.09	1.07	0.38	0.33	0.15	0.15	9.6	-2.1	-10	-8.2	7.1	10.9	94.5	85.7
34	0.66	0.95	0.59	0.57	0.13	0.13	0.6	11.8	-8.5	13.3	8.9	12.8	80.3	72.5
35	1.25	1.01	0.47	0.65	0.17	0.17	18	4.8	4	3.9	7.1	19.1	89	84
36	1.17	0.68	0.55	0.55	0.14	0.14	0	15.5	3.8	7.2	8	12.8	80.4	75.3
37	1.38	0.72	0.37	0.44	0.11	0.11	26.3	0.4	-1.6	-4.7	8.7	12.6	93.3	61.6
38	1.33	0.9	0.32	0.31	0.15	0.15	8.4	3.2	3.8	13.3	8.3	25.4	64.5	69.2
39	0.5	0.36	0.6	0.57	0.33	0.33	12.9	27.8	-9.2	3.9	11	13.8	84.9	73.1
40	0.5	0.89	0.73	0.46	0.15	0.15	-0.2	4.3	-7.3	7.2	6.2	10.3	77.4	69.2