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A COMPARATIVE STUDY OF LOWER EXTREMITY ANGLES IN PATIENTS WITH PATELLOFEMORAL PAIN SYNDROME (PFPS) COMPARED TO NORMAL SUBJECTS DURING STANCE PHASE OF GAIT CYCLE

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ABSTRACT

Background: PFPS commonly leads to anterior or retro patellar knee pain. The etiology of PFPS is multi-factorial and various studies have identified abnormal patellar tracking, patellar malalignment, abnormal subtalar motion, decrease in navicular angle as some of the possible factors which might lead to PFPS. This comparative study investigates the lower extremity alignment during stance phase of gait cycle in subjects with and without patellafemoral pain syndrome.

Methods: In this experimental study 14 male subjects suffering from PFPS were taken into Group A and 20 asymptomatic male subjects were taken into Group B. Video analysis of both groups were done in anterior, posterior and sagittal view. Still frames of initial contact, mid stance and terminal stance phases of the gait cycle and five angles i.e. standing foot angle, navicular angle, Q angle, A angle and rear foot angle for each of three phases were measured with image tool software.

Result: The mean data showed that the standing foot angle, navicular angle, Q angle, A angle were increased in asymptomatic group when compared to the PFPS group in initial contact, mid stance and terminal stance but these increase in angles were not statistically significant. However the increase in rear foot angle in terminal stance of normal subjects compared to PFPS group was statistically significant (p value= 0.047)

Conclusion: There exists an association of lower extremity angles with PFPS. Significant difference exists with respect to rear foot angle between PFPS and asymptomatic individuals. Rear foot angle decreases during the terminal stance in the PFPS subjects when compared to asymptomatic subjects

Keywords: Patellofemoral Pain Syndrome, Standing foot angle, Navicular angle, Q angle, A angle, Rear foot angle

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INTRODUCTION

Patellamal-tracking, induces pain and abnormal tissue stresses, and acts as a contributing factor to PFPS [1]. PFPS has been defined as the anterior/retro patellar pain which increases with sitting, kneeling, ascending-descending stairs and squatting in absence of other pathology. The etiology of PFPS appears to be multifactorial [1,2]. Gait study by Sylvie et al in PFPS subjects reveal that there is no significant kinetic changes in gait pattern even though there was a decrease in knee flexion angle [2]. Patellar malalignment may be one of the possible etiological factor [2,3,4]. Abnormal patellar alignment reduces the contact area between the patella and femur leading to increase in patellofemoral joint stress. To assess patellafemoral alignment investigators measure Q angle, A angle and patellar orientation [4]. Frontal plane analysis of peak heel strike transient vertical force with timing and the rear foot angle suggests that simultaneous rear foot everted posture may increase heel strike transient magnitude[5]. But despite diminished stance phase knee flexion during fast walking PFPS subjects did not reveal increased lower limb loading.[6]So, it was thought that PFPS can result from abnormal rear foot motion as prolonged rear foot eversion during stance phase of walking will alter loading forces at the knee [7,8]. Tibial rotation increases with increase in pronation and this leads to disturbance in the normal tibiofemoral rotational relationship and change in patellafemoral mechanics [8,9]. External rotation of tibia with subtalar joint pronation is a major contributor for patellofemoral dysfunction [9]. Typical stance phase foot motion has been described in relation to the fore foot: rear foot model and rear foot: leg model of motion together with profiles of medial longitudinal arch height and GRF [10]. There is a statistically significant relationship between fore foot angle and relaxed rear foot angle. There is also a statistically significant relationship between fore foot angle and navicular drop in healthy subjects [11]. Navicular angle is considered as a re liable tool for measurement of foot arch [12]. The relationship between Q angle and PFPS is also controversial since a study on Q angle in anterior knee pain syndrome suggests increased Q angles were not responsible for anterior knee pain [13]. Further a study on the influences of Q angle on tibiofemoral and patellofemoral kinematics showed that increased Q angle leads to lateral patellar dislocation [14]. A study between modified functional index questionnaire (MFIQ), critical angle, eccentric step test and treadmill test concluded that MFIQ is the useful outcome measure which can be used by physiotherapists to measure outcomes in PFPS subjects [15]. A study between the 10 cm visual analog scale (VAS), functional index questionnaire (FIQ) and anterior knee pain scale (AKPS) showed that both AKPS and VAS can be used as a reliable tool for PFPS [16]. The aim and objective of the study is to investigate the lower extremity alignment during various phases of gait in subjects with and without patellofemoral pain syndrome.

METHODOLOGY

In this experimental study a total of 34 adult male subjects were taken. Subjects were recruited from a) Dolphin PG Institute of Biomedical and Natural Sciences, Dehradun, Uttrakhand. b) Dept. Of PMR, Jorhat Medical College & Hospital Assamc) Kamakhya Diagnostics and Physio Rehab Centre, Jorhat, Assam. Based on an assessment and with a medical diagnosis of established PFPS 14 subjects were placed in the PFPS group i.e. (GROUP A) and 20 subjects were placed on the asymptomatic group i.e. (GROUP B) and five subjects were included for the reliability study.

Patients included were male subjects in the age between 20-50 years. In Group A patients with established PFPS were included. In Group B asymptomatic patients were included. However patients with any history of patella dislocation or subluxation, any clinical evidence of meniscal or ligamentous lesions and patellar tendon pathology, history of knee trauma, immobilization of lower extremity, any neurological condition affecting lower extremity, lower limb surgery and hip and ankle pathologies were excluded from the study.

Instrumentation used in the study were Kodak digital camera easy share CX7300 (7.2 megapixels), Tripod stand (Prostar), Measuring tape, Reflective markers, Image tools software (version 3.0) and Black Skin Marker

PROCEDURE

Subjects were informed about the purpose and procedure of the study prior to the participation and informed consent was obtained from them. Subjects were assessed and screened initially as per the screening and the assessment format. Based on this assessment and a medical diagnosis of established PFPS 14 subjects were placed in the PFPS group (GROUP A) and 20 subjects were placed on the asymptomatic group (GROUP B).

The subjects were instructed to wear shorts so that bony landmarks are exposed properly. The subjects were placed in relaxed standing position, and bony landmarks such as ASIS, midpoint of patella, tibial tuberosity, navicular tuberosity, medial malleolus, 1st MTP joint were manually palpated and reflective markers were adhered to these points. Before the recordings subjects were made to walk in the walkway two times so that they get familiar with the procedure and to get their normal pace of walking. The digital camera was placed in the tripod camera stand at a distance of 1.5 meters from the subject. Subjects were instructed to walk in their normal pace in two meters walkway marked with reflective markers at each 0.5 meters distance. For the sagittal view camera was placed at a distance of 1.5 meters sagittally. For the anterior view subjects were instructed to walk in their normal pace facing the camera and the gait pattern was recorded anteriorly. For the posterior view subjects were instructed to walk in their normal pace with the rear foot facing the camera and gait pattern was recorded posteriorly.

All the recordings in sagital, anterior, posterior view were framed for initial contact, mid stance and terminal stance phases of the gait cycle and five angles i.e. standing foot angle, navicular angle,A angle, Q angle and rear foot angle for

each of three phases were measured with image tool software. Procedure was repeated three times for each subject and the mean reading was taken for final analysis.

A reliability study was done initially with five normal asymptomatic individuals to check the reliability of the procedure. The inter rater reliability of the procedure which was found to be reliable (∞ = 0.09).

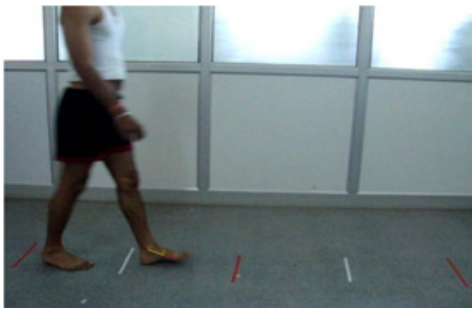


Figure 1: Navicular Angle - Angle between the 1st MTP, navicular tuberosity and medial malleolus.)

Figure 2: Standing foot angle -Angle between the navicular tuberosity, medial malleolus and medial femoral condyle.

Figure 3: Q angle - Angle formed between the line connecting the ASIS to the midpoint of patella and the extension of a line connecting the tibial tubercle and midpoint of patella

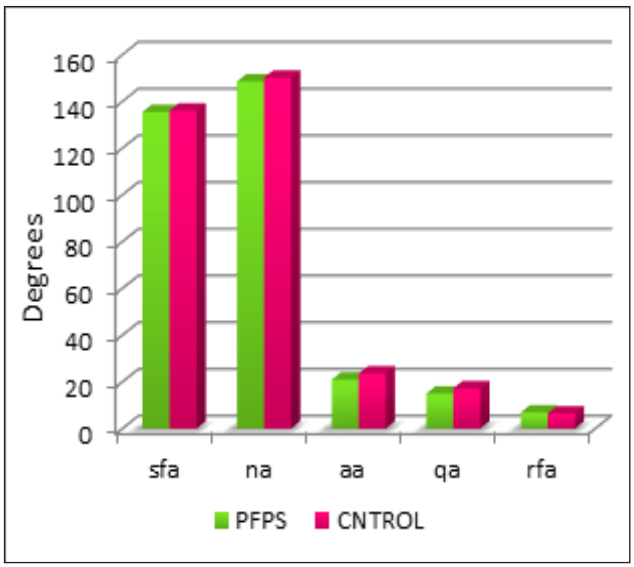
Figure 4: A angle- angle formed between vertical line that divides the patella into two halves and the line drawn from the tibial tubercle to the apex of the inferior pole of the patella.

Figure 5: Rear foot Angle

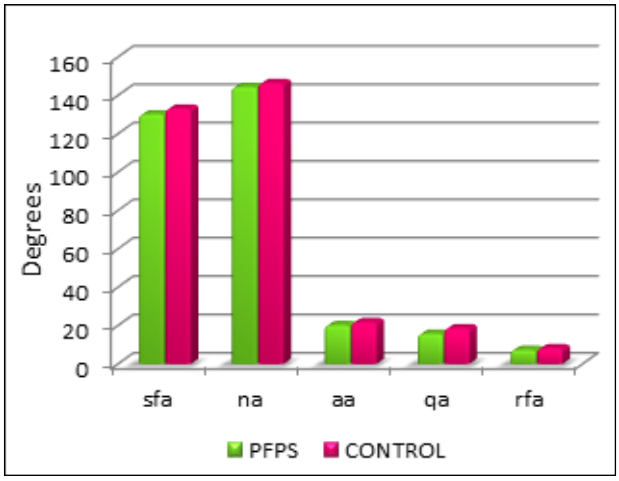
Subject was positioned prone with the foot extending over the end of the examining table. Then mid line of the calcaneus was marked at the insertion of Achilles tendon, then a second mark is made approximately at a distance of 1cm distal to the first mark as close to the mid line of the calcaneus as possible. A calcaneal line was then made to join the two marks. Then two marks are made at the lower third of the leg in mid line, these two marks are joined forming the tibial line representing the longitudinal axis of the tibia. The angle formed between the tibial line and the calcaneal line forms the rear foot angle.

DATA ANALYSIS AND RESULTS

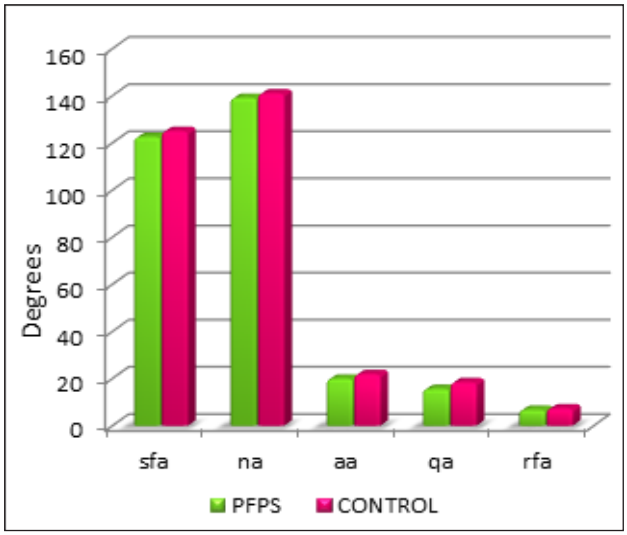
SPSS version 11.0 was used for data analysis. The statistical significance was set at 0.05 at 95% confidence interval and p value < 0.05 was considered significant.Unpaired t- test was used for analysis of the data comparison between the groups.The mean data showed a difference between the two groups in all five angles i.e. standing foot angle (sfa), navicular angle (na), quadriceps angle (qa), A angle (aa) and rear foot angle (rfa). All the angles were increased in asymptomatic group when compared to the PFPS group. This trend was followed in all angles at the 3 positions of the stance phase i.e. initial contact, mid stance and terminal stance.



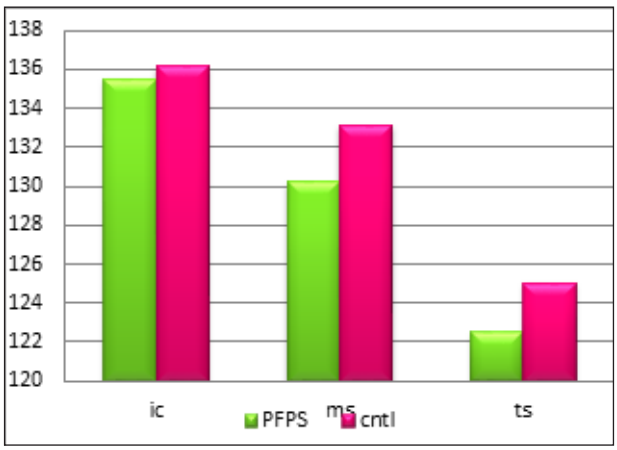
Graph1: Comparison of angles between the groups at initial contact (ic).



Graph 2: Comparison of angles between the groups at mid stance (ms).



Graph3: Comparison of angles between the groups at terminal stance (ts).

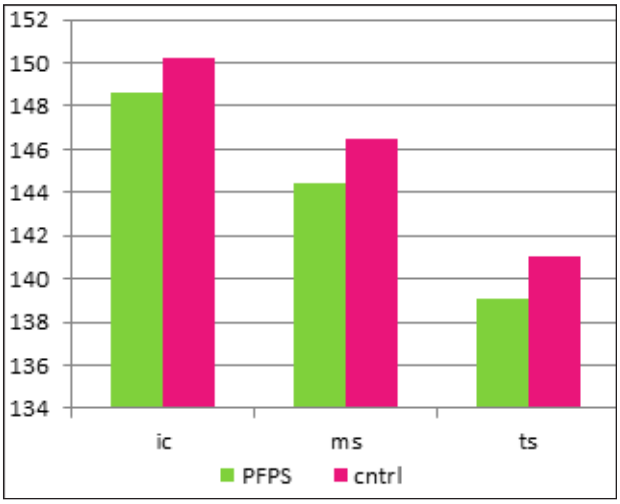


Graph 4: Standing foot angle (sfa) between the two groups in degree

Gait cycle	PFPS	Asymptomatic	P value
Initial contact	135.5± 69.25	136.1± 9.24	.708
Mid stance	130.2 ± 10.71	133.1 ± 11.33	.832
Terminal stance	122.5± 12.13	125.0 ± 14.79	.310

Table1: Standing foot angle (sfa) between the two groups in degree

The standing foot angle was observed to have lower angles in the PFPS group in comparison with the asymptomatic group, but the difference was not statistically significant. This angle decreased from initial contact to mid stance and then from mid stance to terminal stance in both the groups.

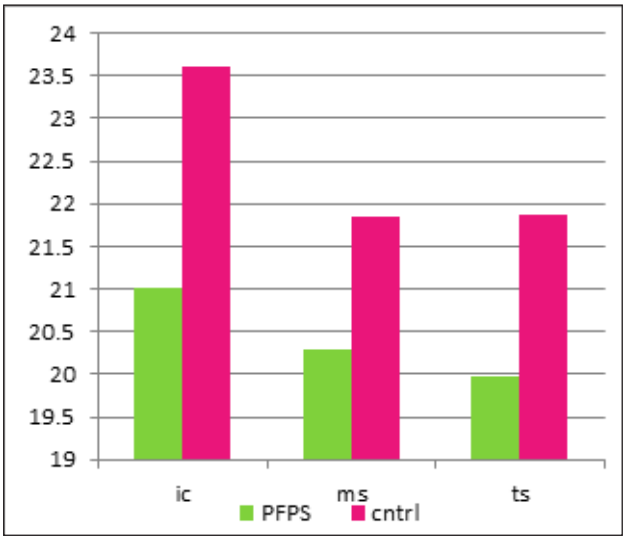


Graph 5: Navicular (na) angle between the two groups in degrees

Gait cycle	PFPS	Asympto-matic	P value
Initial contact	148.6 ± 11.14	150.2 ± 11.92	.783
Mid stance	144.4 ± 10.39	146.5 ± 11.14	.375
Terminal stance	139.1± 14.11	141.0 ± 14.10	.831

Table 2: Navicular angle (na) between the two groups in degrees

The navicular angle showed a decrease in the stance phase from initial contact to midstance through terminal stance. The decrease was seen in both groups i.e. control and PFPS. The data also revealed that these angles were lower in PFPS group than the asymptomatic group irrespective of the position of the foot. But the difference between the groups was not statistically significant

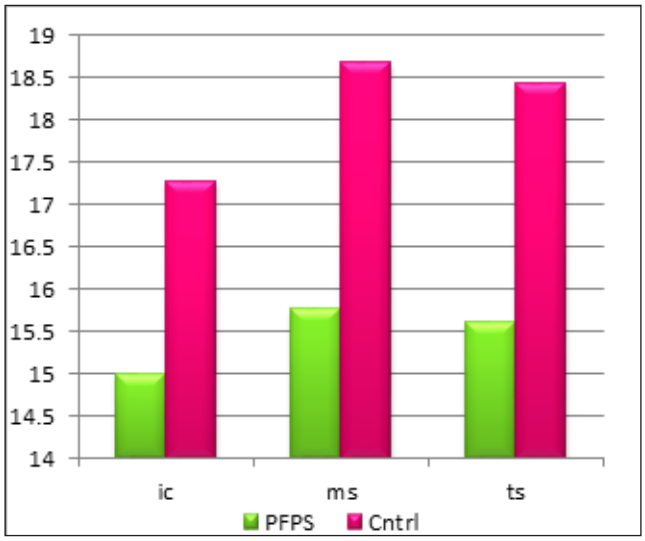


Graph 6: A angle between the two groups in degrees

Gait cycle	PFPS	Asympto-matic	P value
Initial contact	21.01 ± 8.69	23.61± 5.45	.783
Mid stance	20.2 ± 8.03	21.8 ± 5.33	.093
Terminal stance	19.9 ± 7.69	21.8± 8.34	.762

Table 3: A angle between the two groups in degrees

The results reveal that A angle had lower values in the PFPS group than the asymptomatic group. The angle decreased from initial contact to mid stance in both the groups, but from mid stance to terminal stance the angle showed a decrease in the PFPS group but remained same in the asymptomatic group.The difference was not statistically significant.

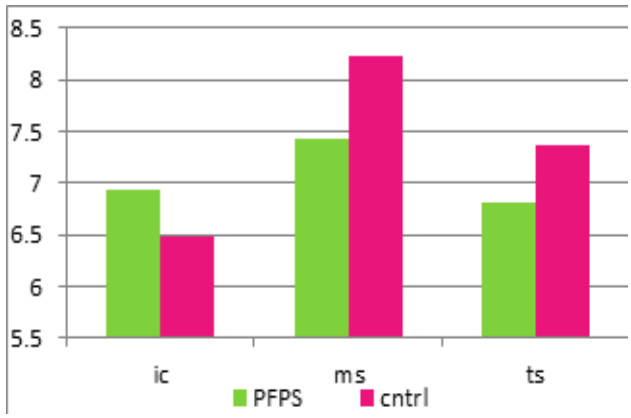


Graph 7: Q angle between the two groups in degrees

Gait cycle	PFPS	Asymptomatic	P value
Initial contact	14.9 ± 5.59	17.2 ± 5.21	.806
Mid stance	15.7 ± 5.07	18.6 ± 4.89	.712
Terminal stance	15.6 ± 7.15	18.4 ± 6.67	.984

Table 4: Q angle between the two groups in degrees

The Q angle showed an increase from initial contact to mid stance and showed a decrease from mid stance to terminal stance and this difference was seen in both the PFPS and asymptomatic group (Graph 7 & Table 4). As a whole it showed lower angles in the PFPS group than the asymptomatic group though statistically insignificant.

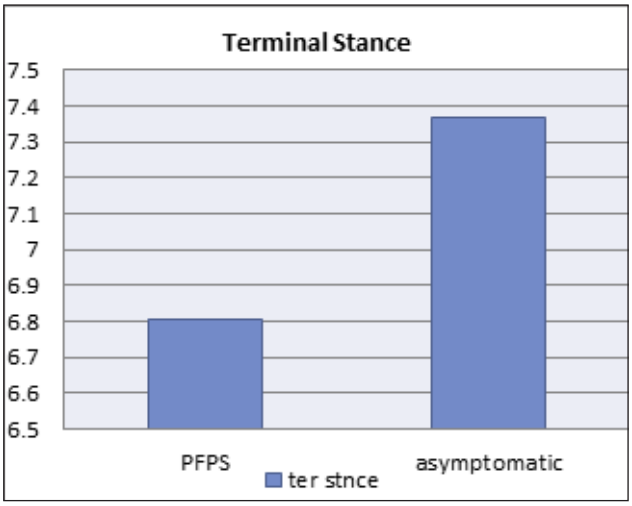


Graph 8: Rear foot angle (rfa) between the two groups in degrees

Gait cycle	PFPS	Asymptomatic	P value
Initial contact	6.9 ± 4.41	6.4 ± 3.72	.780
Mid stance	7.4 ± 3.66	8.2 ± 3.89	.498
Terminal stance	6.8 ± 2.97	7.3 ± 4.38	.047

Table 5: Rear foot angle (rfa) between the two groups in degrees

The rear foot angle showed higher angles in the PFPS group during the initial contact but showed lower angles during the mid-stance and terminal stance. The angle increased from initial contact to mid stance and then decreased from mid stance through terminal stance in both the groups. Statistically significant difference in the rear foot angle was seen during the terminal stance between the both groups (Graph8). The difference was seen as lower degrees in the PFPS group in comparison to the asymptomatic group.



Graph 9: Comparison of rear foot angle (rfa) between the two groups during terminal stance(ts)

Gait cycle	PFPS	Asymptomatic	P value	T value
Terminal stance	6.8 ± 2.97	7.3 ± 4.38	.047	.685

Table 6: Comparison of rear foot angle (rfa) between the two groups during terminal stance(ts)

DISCUSSION

The findings of the study reveal that lower extremity alignment is altered in population with patellofemoral pain syndrome during the stance phase of gait cycle. It was observed in the results that all the five angles had lower mean values in the PFPS group when compared with asymptomatic subjects during the whole stance phase of walking irrespective of the position of foot. But significant difference was found only in case of rear foot angle during the terminal stance. Sylvie N et al., suggested that PFPS subjects alter their gait pattern in order to reduce loading of the patellofemoral joint to avoid pain [2]. David and Arthur proved both Q angle and A angle measurements to be unreliable when evaluated through clinical estimation and instrumented measurements [4]. It can be hypothesized that the lower values in the PFPS population could be because PFPS subjects altered their gait pattern for compensation over years for the changed lower extremity alignment.

The standing foot angle refers to the angle formed between the lower leg and foot. Pazit and Wendy proved that earlier dorsiflexion of the rear foot relative to the tibia could affect the knee joint in PFPS subjects. In PFPS subjects, prolonged rear foot eversion occurs during stance phase of walking which could affect transfer of loading forces to the knee [7]. The standing foot angle showed a decrease from initial contact to terminal stance in both the groups in accordance with the normal biomechanics. In the present study PFPS population had lower standing foot angle compared to the asymptomatic subjects during whole stance phase. So it can be hypothesized that this could lead to hyper pronation at the subtalar joint and subsequent internal rotation of the tibia associated with lateral tracking of the patella in PFPS subjects. But the results of this study have concluded that there is no statistically significant difference between the PFPS population and asymptomatic subjects. So it cannot be concluded that the difference between the groups was due to some altered mechanics in the lower extremity. The results have revealed that navicular angle is decreased from initial contact to terminal stance in both the groups. David and MS suggested that increased internal tibial rotation with excessive pronation led to alteration in the normal patellofemoral kinematics [9]. Because of this hyper pronation, navicular bone must have dropped which could have lowered the navicular angle in PFPS population. However there was no statistically significant difference of navicular angle in the study.

The results have revealed that A angle decreased from initial contact to terminal stance in PFPS population. In asymptomatic population A angle decreased from initial contact to mid stance but remained unaltered till terminal stance in accordance with the normal mechanics. It was seen that PFPS population had lower A angle than the asymptomatic population. This could be due to the lateral tracking of the patella that occurs in the PFPS population. But since the difference between the groups was not found to be significant in the results so it cannot be inferd that difference between the groups was due to the malalignment in the patellar kinematics. Kirsten and Irene2005, Wang et al 2003 properly described the normal kinematics of patella [11,12]. When the Q angle during stance phase of gait, it was observed in the results that Q angle had an increase from initial contact to mid stance and a decrease was seen from mid stance to terminal stance. Lower Q angle was seen in the PFPS group than the asymptomatic group. In this study the increase in the Q angle from initial contact to mid stance and its decrease after mid stance was in accordance with the normal kinematics of patella [11,12]. Since the difference between the groups was not found to be significant it cannot be inferd this relationship during the gait in patellofemoral pain syndrome subjects. Judi and Raymond 2005, found that at initial contact, the subtalar joint inverts approximately 2-3 degrees in normal individuals [17]. Mid stance –Judi and Raymond 2005, says that immediately after the initial contact rapid eversion of the calcaneus begins and continues until the mid-stance where a maximally everted position of approximately 2 degrees is reached [17]. Terminal stance- according to Judi and Raymond 2005, normally a relatively neutral position of calcaneus is reached at about 40-45 percent of cycle at approximately terminal stance [17] The results reveal that the rear foot valgus angle showed a gradual increase from initial contact to mid stance and showed a decrease from mid stance to terminal stance during the stance phase of the gait cycle in accordance with the biomechanics of foot during the gait [18].

Anh-Dung and Michelle [2009] speculated that based on the coupling between rear foot frontal motion and tibia rotation, excessive pronation results in abnormal tibial rotation which increases stress on the patellofemoral joint [19]. In this study, PFPS group had higher rear foot valgus angle than the asymptomatic group during the initial contact. Present study reveals that during the mid stance PFPS population had lower rear foot angle. Lower rear foot angle infers that the rear foot inverted during the mid stance in the PFPS subjects. This could be due to the early recruitment of the tibialis posterior muscle during the mid stance which supinated the subtalar joint and thus inversion of the calcaneus and lower rear foot valgus angle. The results showed a significant decrease in the rear foot valgus angle in the PFPS subjects during the terminal stance. According to Anh-Dung and Michelle 2009 that maximum knee flexion occurs during terminal stance so patella femoral contact pressures are most prone to increase during the terminal stance [19]. Thus the study conclude that in PFPS, subject's inversion of the rear foot occurs during terminal stance to compensate for the abnormal mechanics and to alleviate pain in the Patellafemoral joint. The study had certain limitations like a very small sample was recruited for the study. The subjects included into the study were only male subjects. And lastly gold standard outcomes were not used in this study.

CONCLUSION

There exists an association of lower extremity angles with PFPS. Significant difference exists with respect to rear foot angle between PFPS and normal asymptomatic individuals. Rear foot angle decreases during the terminal stance in the PFPS subjects.

Appendix 1: Abbreviations

PFPS :Patellofemoral Pain Syndrome
IC : Initial Contact
MS : Mid Stance
NA: Navicular Angle
QA: Quadriceps Angle
RFA: Rear Foot Angle
SFA: Standing Foot Angle
TS: Terminal Stance

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