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ORIGINAL RESEARCH

Is There a Relation between The Lower Extremity Mechanics and Patellofemoral Pain Syndrome?

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Abstract
Objective: It has been theorized that changes in the lower extremity mechanics may lead to develop Patellofemoral Pain (PFP) in the young population. The present study aims to investigate the effects of lower extremity mechanics on Patellofemoral Pain Syndrome in private university students.
Material-Method: Kujala Patellofemoral Score (KPS) of 400 Yeditepe University students ages of 18-30 years was performed**.** Students having a less or equal point of 85 in KPS (n=30) and healthy groups randomly selected in students with KPS=100 (n=30) were measured in terms of Feiss Line, navicular drop, subtalar angle, tibial torsion, knee valgus angle, Q angle in standing and supine position and hamstring tightness.
Results: The prevalence of PFP among students was found to be 10.5% (n = 42). In the PFP group, 16 (%53.3) students and in the control group, 3 (%10) students had 2nd Pes Planus (PP). A statistically significant difference was found between groups in navicular drop, subtalar angle, tibial rotation, Q angle in supine and hamstring tightness (p-value <0.05).
Conclusion: The results from this study show that students with PFP have higher severity degrees of pes planus, navicular drop, subtalar angle, tibial torsion, and hamstring tightness than nonpainful students. Therefore, these parameters that are related to lower extremity mechanics may be investigated in PFP examination and be considered while preparing a treatment plan.
Keywords: Pes Planus, Patellofemoral Pain, University Students.

INTRODUCTION

Patellofemoral Pain (PFP) is frequently seen in physically active populations, especially in young adults and mostly greater in females compared to males[1]. Squat position, ascending, and descending stairs or hills, sitting a long time with knees in flexion may elicit the onset of pain in PFP[1,2]. Pain at the patellofemoral joint during described positions or activities may lead to restrictions to participation in physical activities among young adults[3].

Lower extremity alignment may have an important role to understand the pathogenesis of PFP[2,4]. It starts with an abnormal form of the feet especially pes planus (PP), which is related to the absence of medial longitudinal arch and excessive pronation (hind foot valgus)[5]. To control this abnormal pronation, the tibia rotates and forces the knee to valgus, which may cause a decrease in the contact surface of patella and femur. The position of patella affects the Q angle, which is also known as "quadriceps angle." As a result, excessive compression to lateral patella facets and abnormal patella tracking may lead to PFP[4,6].

Muscle tightness or shortness is frequently reported as an objective sign in Patellofemoral Pain Syndrome (PFPS) patients and represents a target for treatment. Actually, relieving the tightness of specific muscles is the common clinical target in physiotherapy. Although the effect of hamstring tightness is thought to affect knee pain[7], in the literature, the impact of muscle length on PFPS is investigated for a group of muscles[8], such as hamstrings, tensor fascia lata and quadriceps. There are several studies revealing the individual effect of hamstring tightness on knee pain[9]. However, the results of those studies are unclear to explain the association between hamstring tightness and knee pain.

There are several factors; such as, muscle weakness, overuse, and lower extremity mal-alignments that may contribute to PFP. However, the consensus on the etiology of PFP is not defined[4]. Moreover, in the literature, there are a limited number of studies investigating the risk factors of this problem in a particular population[9].

Plenty of uncertain contributing factors to PFP may be the main reason why there is no definitive treatment[1,4]. Describing the cause of PFP at the early stages of life, before pain becomes worse at an older age, may be the key to the treatment. The purpose of this study was to investigate the prevalence of PFP among private university students and to investigate and compare the lower extremity mechanics of students with and without PFPS. It was hypothesized that students with PFPS would have more pes planus degree, navicular drop, subtalar angle, tibial rotation, and Q angle than students without PFPS.

MATERIALS AND METHODS

Study design

The present study was a case-control design study and was conducted from 04. 04. 2018 to 10. 08. 2018. The subjects were asked to sign an informed consent form that had been approved by the Human Research Ethics Committee of Yeditepe University in 04.04.2018 (Approval number: 37068608-6100-15-1469)

Participants

Four hundred university students aged between 18 and 30 years were included in this study. Students were asked to fill the Kujala Patellofemoral Score (KPS) to determine the PFP status. 30 patients who had 85 or lower scores were included in the PFP group[10]. Sixty students who had PFP were excluded due to other orthopedic problems (n=48) or unwilling to participate in evaluations (n=12). Also, thirty students who had higher scores from KPS were included in the present study as a control group. Participants excluded from the study if there is a trauma and fracture history of the knee or lower extremity, a musculoskeletal system surgery, a diagnose for any disease of lower extremity, a regular usage of drugs which may influence muscular, skeletal, or neurological systems, or an in-line injection and systemic diseases (Figure 1)

Outcome measures

Kujala Patellofemoral Scoring Questionnaire was developed for the people who have PFP by Kujala et al.[11] in 1993. Also, validity, reliability, and sensitivity of this questionnaire was shown by Crossley et al.[12]. For this research, the Turkish version of the Kujala, which is demonstrated by Kuru et al. was used[1]. This questionnaire has 13 questions asking about how the pain is during a weight-bearing position, walking, jumping, running, squatting, ascending, and descending stairs and sitting with the knee bent in a long time. Also, the questionnaire asks the patients if they have complaints of swelling, limping, abnormal painful kneecap, atrophy of thigh muscles, flexion deficiency, and inquire that whether weight bearing is painful or not. It is determined that the highest point is 100, and the lowest one is 0[1,11,12].

Pes planus was measured by the Feiss line. The navicular tuberosity, the apex of the medial malleolus, and the plantar aspect of the first metatarsophalangeal joint were marked with pencil on patients in sitting position than standing position. For a first-degree flatfoot, the tubercle had to fell one-third of the distance to the floor; for a second-degree flatfoot, it had to fell two-thirds of the distance; if it was very closed to the floor, it meant a third-degree flatfoot. The difference between the height of navicular tuberosity from the ground in sitting and standing positions was recorded as "navicular drop"[13].

Subtalar angle was measured by recording the midline of Achilles tendon and ankle joint, and the midline of the calcaneus with the ruler. Then, the pivot point was the midline of the ankle joint. Next, the angle between Achilles and calcaneus line was measured in both prone and standing positions. The difference between standing and prone position of subtalar angle was recorded with goniometer in degrees for three times. For example, if the subject in prone position had 3 degrees of varus and in standing position had 4 degrees of valgus, the difference between them was recorded as 7 degrees[14].

Tibial torsion was measured by checking the line between apexes of medial and lateral malleolus according to the floor in the supine position. The angle between the lines was calculated with the goniometer as a tibial torsion for three times, and the average value was recorded in degrees[13].

Knee valgus angle measurement was performed with a goniometer in the upright position. After marking the mid popliteal pili, one arm of the goniometer was placed to the tuber ischium popliteal pile, and other arm was placed on the

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popliteal pili and mid-line of Achilles tendon. This value was measured for three times, and the average value was recorded in degrees[14].

The Q angle was measured in two different positions (supine position and standing with the double limb) by using the lines between (Anterior Superior Iliac Spine) ASIS and the mid-point of the patella, and the mid-point of the patella and the tibial tuberosity[13].

Hamstring tightness was measured by 90/90 Passive knee extension test, which has excellent inter-rater and good reliability[15]. While testing the participants in the supine position, knee and hip were taken 90-90-degree flexion, then one arm of the goniometer was placed on the femur and other on fibula and knee moved passively to the extension. Then, the angle between the fibula and the floor was noted. This measurement was applied for three times, and the average results revealed the tightness of hamstring numerically[16].

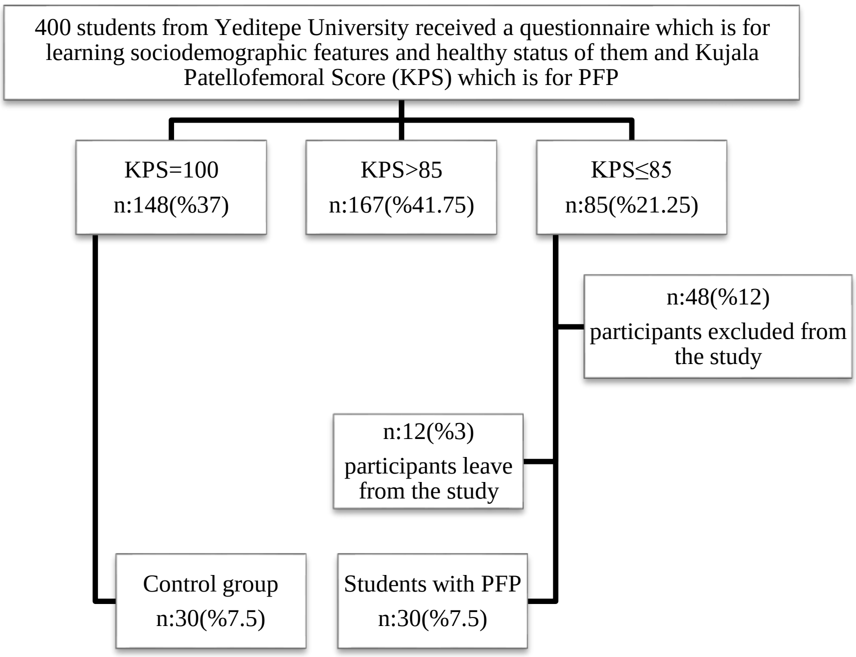

Figure 1. Distribution of subjects in the study. “PFP” and “n” indicates Patellofemoral Pain and number of students respectively.

Statistical analysis

Statistical Package for Social Sciences (SPSS) Version 25.0 program was used for the data analysis. Descriptive statics, mean ± standard deviation (X ± SD) or percentages (%), were gathered. The level of significance was accepted as p-value <0.05. Before statistics analysis, One-Sample Kolmogorov-Smirnov normality test was applied to obtained data. For comparison of groups Mann Whitney U test was used.

RESULTS

The demographic and clinical characteristics of participants showed in Table 1. The mean age was 22 ± 1.41 years in the PFP group, and that for the control group was 22.6 ± 1.32 years.

Data expressed as mean and ± standard deviation. Mean values expressed as are significantly different at $p < 0.05$ and $p < 0.01$.

Table 1. Demographic data in students with PFP and Control Groups [a]

	PFP Group(n=30)	Control Group(n=30)	p value
Female (n[%])	24(%80)	24(%80)	
Age (years)	22.0±1.41	22.6±1.32	0.158(NS)
Height (cm)	166.70±7.52	169.46±7.96	0.172(NS)
Weight (kg)	60.35±12.08	62.16±13.66	0.615(NS)
BMI	21.56±3.05	21.45±3.40	0.779(NS)

BMI, body mass index (kg/m^2);n, number of subjects; NS, nonsignificant difference; PFP, patellofemoral pain.

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This study showed that the prevalence of PFP in a private university was 10.5%. Besides, the frequency of the PFP syndrome among women and men was revealed as 9% and 1.5%, respectively (Figure 2).

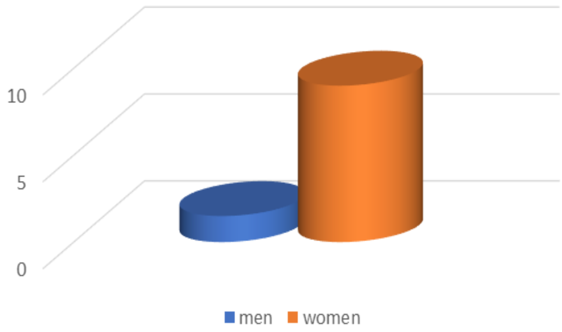

Figure 2. Distribution of percentage of gender in PFP individuals.

While 16 (%53.3) students in the PFP group had 2nd degree PP, 3 (%10) students in the control group had 2nd degree PP. Compared to controls, 14 (%46.7) students had 1st degree PP in the PFP group (Figure 3).

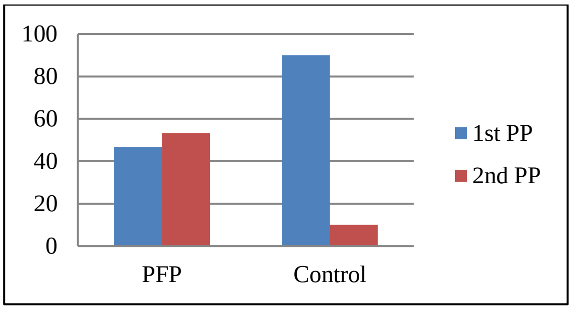

Figure 3. Distribution of the percentage of pes planus degrees between students with PFP and healthy students

The navicular drop, subtalar angle, and tibial torsion were found significantly higher in the PFP group than the control group ($p<0.05$) (Table 2). While the Q angle showed statistically significant results in the PFP group, compared to controls in the supine position ($p<0.05$), in the standing position there was no significant difference of Q angle in between the groups ($p=0.06$). Table 2 also demonstrates that there was no significant difference in genu valgum angle between the groups ($p=0.257$). 90/90 Hamstring tightness test showed statistically significant results in the PFP group compared to controls ($p<0.05$) (Table 2).

Table 2. Lower limb measurements in students with PFP and control groups.

	PFP Group(n=30) Mean±SD	Control Group(n=30) Mean±SD	*p value*
Navicular drop(mm)	5.06±2.42	2.50±1.71	***0.000a***
Subtalar angle (°)	5.30±3.49	2.7±1.66	***0.004a***
Tibial torsion (°)	12.04±3.64	10.33±2.83	***0.040b***
Q angle in supine position (°)	19.63±4.28	15.7±3.93	***0.001a***
Q angle in standing position (°)	19.56±4.86	17.15±4.62	*0.063*
Genu valgum angle(°)	8.74±3.59	7.79±3.48	*0.257*
90/90 Hamstring tightness test(°)	14.06±6.12	6.55±3.96	***0.000a***

**According to results of Mann Whitney U test*
SD, Standard Deviation; n, number of subjects; PFP, Patellofemoral pain
Data expressed as mean and ± standard deviation. Mean values expressed as are significantly different at $p<0.05$ and $p<0.01$.

DISCUSSION

This study showed that the prevalence of PFP in a private university was 10.5%. Besides, the frequency of the PFP syndrome among women and men was revealed as 9% and 1.5%, respectively (Figure 2). Similarly, to the results of Roush JR. and Curtis R[17], in our study women were more likely to have PFP than men, which may be a result of the alterations of lower extremity biomechanics in women, such as, the wider pelvis and larger Q angles.

In the literature, the reason for having PFP has not been adequately clarified yet. One of the risk factors might be pes planus since the foot posture may affect the lower extremity alignment[18]. To the best of our knowledge, even though the relationship between PFP and pes planus has theoretically known, literature has been debatable about this topic.

In the current study, in the PFP group, 16 (%53,3) students and in the control group, 3 (%10) students had 2nd PP. Our results showed the number of students having first- and second-degree PP was higher in the PFP group (Figure 3). As in our study, Kosashvili et al.[18] reported that moderate and severe PP might be associated with PFP among adolescents. Therefore, it may be recommended that patients with PFP may be assessed and treated in terms of the posture of the feet.

The present study demonstrated that subjects with PFP had significantly higher navicular drop results than subjects in the control group (Table 2). Consistent with our study results, Barton et al.[19] reported that subjects with PFP had significantly higher navicular drop results compared to controls. Similarly, Mølgaard et al.[20] have also shown that patients with PFP had a higher navicular drop and navicular drift diverge than their control groups. Therefore, it is possible to conclude that individuals who have a navicular drop may have an increased risk for PFP.

According to our results, a significant difference between the two groups was found in terms of subtalar angle (Table 2) (p=0.00). Our results also showed a greater subtalar angle in the PFP group compared to the control group. Similar results were reported by the research of Dileep et al.[21], in which the patients with PFP within the ages of 20-30 years were evaluated according to their foot posture and PFP syndrome and found an association between these two components. In contrast to our study, Hetsroni et al.[22] concluded that there is no consistent association between the incidence of anterior knee pain and foot pronation by measuring the subtalar joint displacement angle. Different from the study of Hetsroni, we selected a quite narrow age ranges to prevent the interference of age-related problems. With the selection of a population within specific age, we aimed to emphasize the mechanical links to PFP. Therefore, these controversial issues may result from the simultaneous evaluation of many risk factors that can cause PFP in the studies. Since there is more than one risk factor affecting PFP, lower extremity biomechanics may be recommended to be evaluated separately.

In this study, the mean values of tibial torsion in the PFP group were higher than the control group. In the PFP group had significantly greater tibial torsion compared to subjects in the control group (Table 2) (p = 0.04). Powers et al.[23] reported that tibial torsion and foot pronation were not different between subjects with and without PFP. In contrast to Powers et al.[23], Levinger and Gilleard[24] found greater inversion angle of the subtalar joint and eversion of the calcaneal joint in women with PFP compared to controls. Increased pronation of the foot may be considered as a cause of PFP and may mechanically cause tibial torsion in subjects with PFP. Besides, abnormal movement of the subtalar joint leads to the abnormal tibial rotation, which may result in injuries of the lower limb.

In this study, even though the Q angle in the supine position was different between groups (p=0.00), the Q angle in standing position was not significantly different (Table 2) (p=0.06). According to mean values, the Q angle in supine and standing positions were higher in the PFP group than the other group (Table 2). Some studies showed that an increased Q angle (greater than 20°) might lead to increased retro-patellar pressure, which may result in PFPS and degeneration of the articular cartilage. However, this issue has been controversial in the current literature (4). In their study, Kaya et al.[25] showed that individuals with PFP had significantly higher Q angle degrees in standing position than the individuals without PFP. On the contrary, the results of Caylor et al.'s study[26] did not reveal any difference between the Q angle degrees of the subjects with or without PFP in the standing position. In the current literature, the Q angle, being an indicator of PFP, has remained suspicious. However, it has been one of the most frequently used parameters to evaluate the risk of PFP among patients with PFPS[13]. Therefore, the effects of the Q angle are still discussed for subjects with or without PFP as the same in the literature.

Our genu valgum angle results were not statistically significant between PFP and control groups (Table 2). However, the mean of the genu valgum angle was higher in the group with PFP than in the control group (Table 2). Consistent with our study results, a systematic review of 973 study summaries and 20 full-text articles examining the predisposing factors of PFPS reported that static knee valgus was not associated with PFPS[27]. Despite the results of some studies showing a low association of genu valgum in PFP, it is still considered to be a risk factor in clinical practice as the expectation of the clinicians is in the way that genu valgum may cause lateralization of the patella[28].

Likewise, the study of White et al.[29], which revealed an increased hamstring tightness in the PFP group, in our study, a significant increase in terms of hamstring tightness was apparent in the PFP group compared to control group. Consistent with our study results, a systematic review reported that hamstring tightness might be the contributing factor of PFP since it may also cause a decrease in knee flexion to result in increased quadriceps forces[30]. Therefore, hamstring tightness may induce PFP by overloading the patella-femoral joint.

Limitations of the study

In our study, we used the score of Kujala to determine the PFP, feiss line to measure the navicular drop. However, more objective assessments, such as MR images of patellofemoral joint or kinematic analysis, could be used to increase the reliability.

CONCLUSION

The prevalence of PFP in students of a private university was found % 10,5 (n=42). The results from this study showed that students with PFP have higher severity degrees of pes planus, navicular drop, subtalar angle, tibial torsion, and hamstring tightness than nonpainful students. However, the effects of Q angle and genu valgum angle on patients with PFP were controversial in our study. The foot type of patients with the PFP should be examined. However, future work should be conducted to determine the correlation between PFP and PP.

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Conflict of interest: There is no potential conflict of interest relevant to this article.

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