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Original Article

Correlation between Intrinsic Patellofemoral Pain Syndrome in Young Adults and Lower Extremity Biomechanics

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Abstract. [Purpose] The purpose of this study was to evaluate the correlation between intrinsic patellofemoral pain syndrome (PFPS) in young adults and lower extremity biomechanics. [Subjects] This experiment was carried out with sixty (24 men and 32 women), who are normal university students as subjects. [Methods] All subjects underwent 3 clinical evaluations. For distinguishing the intrinsic PFPS from controls, we used the Modified Functional Index Questionnaire (MFIQ), Clarke's test and the Eccentric step test. Based on the results of the tests, subjects who were classified as positive for 2 more tests were allocated to the bilateral or unilateral intrinsic PFPS group (n=14), and the others were allocated to the control group (n=42). These two groups were tested for hamstring tightness, foot overpronation, and static Q-angle and dynamic Q-angle. These are the four lower extremity biomechanic, cited as risk factors of patellofemoral pain syndrome. [Results] The over pronation, static Q-angle and the dynamic Q-angle were not significantly different between the two groups. However, the hamstring tightness of the PFPS group was significantly greater than that of the controls. [Conclusion] We examined individuals for intrinsic patellofemoral pain syndrome in young adults and lower extremity biomechanics. We found a strong correlation between intrinsic PFPS and hamstring tightness.
Key words: Hamstring, Patellofemoral, Pain

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INTRODUCTION

Patello Femoral Pain Syndrome (PFPS), which is known to be the most common of knee joint injuries, is a disease with the primary complaint of pain in the front of the knee, and is one of the most common in the knee complaint of young age groups[1)]. PFPS tends to occur more in young adults showing with high activity, and occurs with the highest incidence, 25%, in the 10–35 years, the cause of this disorder has not yet been exactly determined[2)]. PFPS is a disease that has intrinsic, external and internal factors; that is, potential and external risk factors of PFPS are said to be present in sports activities or sports training habits, problems of surrounding environments, and through incorrect use of appliances, etc, as well as internal potential risks due to individual physical characteristics and psychological tendencies[3)]. It has been suggested that the patella is highly affected by its surrounding structures and has high instability, and that the instability of the patella appears to be higher in young adults with high activity than in other age groups[4)].

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PFPS is generally caused by knee dysfunction increasing pressure in the patellofemoral joint contact area due to transformed gliding between the patella and femoral trochlear notch. PFPS is associated with various biomechanical characteristics of the lower extremity, and potential risk factors are: abnormal form of the feet; functional weakness of hamstring and quadriceps muscle of the thigh and the gastrocnemius; shortening of the iliotibial tract; generally weakened joints; excessive quadriceps angle; patellar compression or tilting; and abnormal reaction velocities of the vastus lateralis and vastus medialis oblique[5)]. Different biomechanical factors of the lower extremity limbs have been studied as potential risk factors of PFPS for a long time, but there is a debate over how much each factor affects PFPS, and more detailed studies are needed[6)]. PFPS for a prolonged period in young adults tends to develop into degenerative arthritis of the patellofemoral joint, and symptoms of degenerative arthritis in old age can be predicted. Given this, early diagnosis of PFPS is very important, and PFPS can be fully prevented before surgical intervention is needed via early diagnosis[5)].

In this study, we identified PFPS in university students with various physical characteristics through PFPS diagnosis, and then studied the correlation of PFPS with risk factors that may affect PFPS in terms of the dynamics of the lower extremity, as identified by previous studies, to provide the basic data for the prevention and appropriate treatment of PFPS.

SUBJECTS AND METHODS

The subjects of this study were 60 normal adults who satisfied the selection criteria. In this study, the subjects were 18 to 25-year-old university students. Subjects were excluded if they had any lower limb pathology, neuropathology or any history of previous knee surgery. This was a cross-sectional study, which conducted three kinds of PFPS diagnostic evaluation, the Modified Functional Index Questionnaire (MFIQ), Clarke's test, and the Eccentric step test. Subjects who tested positive in more than two kinds of evaluation (n=14) were classified as the group showing intrinsic PFPS symptoms in one or both knees[7], and the remainder (n=42) were allocated to the normal group. Four subjects were excluded they refused to participate in the experimental measurements. We performed four kinds of biomechanical analyses of the lower extremity that have previously been identified as risk factors of PFPS: shortening of the hamstring muscle, hyperpronation of the feet, and the static quadriceps angle and dynamic quadriceps angle tests. Correlations between intrinsic PFPS symptoms and the 4 variables were investigated. The biomechanical analyses were performed by skilled physical therapists. MFIQ is a measurement tool consisting of 10 questions with a rating scale response. Higher scores indicate more serious problems and the lowest possible score is 0 points. Shortening of the hamstring muscle was measured by measuring the angle of straight leg raised hip joints with a goniometer, and the results of navicular drop test were measured using a graduated ruler. A camcorder was used to measure the dynamic quadriceps angle while descending stairs with one leg bent at the knee and the other leg straight. A SONY DCR-SR 300 (Japan) camcorder was used for the measurement.

For Clarke's test, the subjects lay comfortably on their backs. Then, the experimenter placed one hand on the patella and instructed the subject to contract the quadriceps femoris muscle while he pushed down on the patella. If pain was felt while performing this action, the subject tested positive[8]. For the eccentric step test, the subjects stood barefoot on a 15 cm high step. The subjects were instructed to "stand straight on the step and very slowly lower one leg". If one leg was performed successfully, the subject repeated the procedure with the other leg.

The Navicular Drop Test (NDT) is a method of measuring excessive pronation of the subtalar joint of the feet and it can measure excessive pronation of the feet through the difference in the positions of the navicular bone between without supporting body weight and with supporting body weight[9]. For the hamstring tightness test, the examiner manually lifted the subjects' legs into the straight-leg-raise position. The angle was measured using a goniometer at the outer surface of the pelvis. The measurement was carried out 3 times and the average value was calculated[10]. To measure the static Q-angle, the subjects stood without shoes with their knees straight in a comfortable position while looking straight ahead. After marking the mid-patella, ASIS, tibial tuberosity, we measured the quadriceps angle, the angle between the line connecting the mid-patella and ASIS, and the line connecting the center of tibia tuberosity and the patella[11].

Table 1. General characteristics of the subjects

Parameters	IPFPS (n=14)	CG (n=42)
Gender Male/Female (%)	5/9 (35.7/64.3)	19/23 (45.2/54.8)
Height, cm	167.4 (9.9)	167.1 (8.3)
Weight, kg	62.0 (15.9)	57.64 (9.7)
Age, years	22.1 (3.2)	21.9 (2.6)

Values are n (%) or mean (SD).
IPFPS, Intrinsic Patellofemoral Pain Syndrome; CG, control group

In the dynamic Q-angle measurement, the subjects stood on a 15-cm step, looking ahead and set their feet apart at shoulder width in a comfortable position. Then, the feet were aligned in parallel and the knees straightened. Markers were attached to the ASIS, mid-patella, and the tibial tuberosity of the subjects. When descending from the step on one leg, the subjects took care that the heel on the step. The procedure was repeated it three times for each leg. The data were recorded and analyzed using a motion analyzer (Prosuite ver4.5.2.0, Dartfish, Switzerland). The motions were analyzed together with the images recorded by the camcorder.

SPSS version 12.0 software was used for statistical analyses. For MFIQ scores, the results of Clarke's test and the eccentric step test, and the general characteristics of the intrinsic PFPS group and normal group, frequency analysis and descriptive statistics were conducted. The significance of differences between the groups were examined using the independent t-test, and Spearman's correlation analysis was carried out to determine correlations of intrinsic PFPS with shortening of the hamstring muscle, navicular drop test, static quadriceps angle and dynamic quadriceps angle, which are often used to determine intrinsic PFPS group. A significance level of $p=0.05$ was used.

RESULTS

The general characteristics of subjects are shown in Table 1, and the comparison of MFIQ scores, and Clark's test and the eccentric step test results are shown in Table 2.

The hyperpronation degree of the feet, and the quadriceps angle of the intrinsic PFPS group and normal group did not show significant differences. In the hamstring muscle shortening test, the right lower extremity of the intrinsic PFPS group was significantly shorter than that of the left ($p<0.05$). The dynamic quadriceps angle for observing maximum genu valgum did not show significant difference in the intrinsic PFPS group and normal group (Table 3). The above results show the degree of shortening of the hamstring muscle of the lower extremity correlated with intrinsic PFPS.

DISCUSSIONS

Many patients with PFPS symptom experience spontaneous recovery and even live without any symptoms at

Table 2. Comparison of MFIQ, Clark's test and Eccentric step test scores between groups

Parameters	IPFPS (n=14)	CG (n=42)
MFIQ score		
0	3 (21.4)	35 (83.3)
5	4 (28.6)	4 (9.5)
10	2 (14.3)	0
15	2 (14.3) 2 (4.8)	
25	2 (14.3)	0
35	0	1 (2.4)
50	1 (7.1)	0
Rt. Side Clark's test (+)	14 (100)	11 (26.2)
Rt. Side Clark's test (−)	0	31 (73.8)
Lt. Side Clark's test (+)	5 (35.7)	9 (21.4)
Lt. Side Clark's test (−)	9 (64.3)	33 (78.6)
Rt. Side Eccentric step test (+)	4 (28.6)	0
Rt. Side Eccentric step test (−)	10 (71.4)	42 (100)
Lt. Side Eccentric step test (+)	3 (21.4)	0
Lt. Side Eccentric step test (−)	11 (78.6)	42 (100)

Values are n (%)
IPFPS, Intrinsic Patellofemoral Pain Syndrome; CG, control group; MFIQ, Modified Functional Index Questionnaire

Table 3. Comparison of between groups

Parameters	IPFPS (n=14)	CG (n=42)
Hamstring tightness (°)		
Rt	77.0 (5.9)	80.8 (6.2) *
Lt	78.0 (7.5)	79.4 (7.0)
Static Q-angle (°)		
Rt	19.8 (5.8)	18.0 (5.4)
Lt	20.0 (6.6)	20.2 (6.1)
Dynamic Q-angle (°)		
Rt	18.6 (7.7)	19.5 (8.5)
Lt	21.1 (9.7)	23.6 (9.0)
Navicular Drop Test (cm)		
Rt	1.1 (0.4)	1.0 (0.3)
Lt	0.9 (0.4)	0.9 (0.4)

Values are mean (SD), *$p<0.05$.
IPFPS, Intrinsic Patellofemoral Pain Syndrome; CG, control group

all.[12] In the past, congenital abnormality of the knee articular cartilage or subchondral bone, inappropriate treatment for small damage of the knee, or racial differences were assumed to result in PFPS[3]. However, in modern times, the potential symptoms of PFPS appearing broadly in the knee joints are considered dependent on various lower extremity biomechanical differences. Witvrouw et al.[13], conducted a 2 year follow-up study of potential risk factors of PFPS using students in a physical education and found that significant differences were shown in the hamstring muscle and quadriceps femoris muscle flexibility.

In our present study, 56 healthy university students were tested for PFPS, and 14 subjects, equivalent to 1/4 of all subjects, tested positive for 2 or more items in 3 reliable PFPS clinical evaluations. These subjects were classified as the group with symptoms of intrinsic PFPS. The hamstring muscle of the intrinsic PFPS group was found to be significantly shorter than that of the normal group ($p<0.05$). The imbalance of an agonist generally affects the relation with an antagonist and shortening of the hamstring muscle results in weakening of the quadriceps femoris muscle; therefore, imbalance of the hamstring-quadriceps muscles causes PFPS[14]. Further, shortening of the hamstring muscle means extra power is needed from the quadriceps femoris muscle when extending the knee. This increases the reaction force on patellofemoral joint and causes pain[15, 16].

In this study, the test results of NDT for the group with intrinsic symptoms of PFPS deviated from the normal values, with greater hyperpronation in the intrinsic PFPS group than in the normal group, but the difference was not statistically significant. Excessive pronation of the feet is a factor in musculoskeletal disorders, and reduces the medial longitudinal arch and extends the posterior tibial muscle, calcaneonavicular ligament and plantar fascia, resulting in increased internal rotation of the thigh[17]. Also, as the quadriceps angle increases and the reaction force at the patellofemoral joint increases, internal rotation of the tibia occurs at the same time, affecting the patellofemoral joint and causing pain[18, 19]. Further, excessive pronation of the feet may cause a difference in lower extremity length. Such malalignment of the lower extremity would create imbalance and pressure on the patellofemoral joint and influence the appearance of PFPS symptoms.

Many studies have reported that an excessive quadriceps angle is correlated with PFPS symptoms[11, 20]. If the quadriceps angle exceeds 15 degrees, valgus of the knee appears, and peak knee valgus is also expected to contribute to PFPS through excessive pressures on the knees[21].

According to our experimental results, neither the static quadriceps angle nor the dynamic quadriceps angle of the group with symptom of intrinsic PFPS show a statistically significant difference from the normal group. However, the quadriceps angle exceeds 15 degrees, so secondary risk factors due to an excessive quadriceps angle need to be considered.

In this study, we examined the correlation between biomechanical characteristics of the lower extremity affecting intrinsic PFPS in general university students with various physical characteristics including intrinsic PFPS symptoms. In addition to the four biomechanical parameters selected and analyzed in this study, there are still many controversial biomechanical factors affecting PFPS. Measuring femoral anteversion is considered to be useful for identifying patients with intrinsic PFPS symptoms. Also, studies of correlations of lifestyle, height of heel, sports activities, etc. with students feeling pain in the patellofemoral joint are considered to be meaningful.

REFERENCES

1) Baker V, Bennell K, Stillman B, et al.: Abnormal knee joint position sense in individuals with patellofemoral pain syndrome. J Orthop Res, 2002, 20:

208–214. [Medline] [CrossRef]
2) Muller K, Snyder-Mackler L: Diagnosis of patellofemoral pain after arthroscopic meniscectomy. J Orthop Sports Phys Ther, 2000, 30: 138–142. [Medline] [CrossRef]
3) Darracott J, Vernon-Roberts B: The bony changes in “chondromalacia patellae”. Rheumatol Phys Med, 1971, 11: 175–179. [Medline] [CrossRef]
4) Hamstra-Wright KL, Swanik CB, Ennis TY, et al.: Joint stiffness and pain in individuals with patellofemoral syndrome. J Orthop Sports Phys Ther, 2005, 35: 495–501. [Medline] [CrossRef]
5) Waryasz GR, McDermott AY: Patellofemoral pain syndrome (PFPS): a systematic review of anatomy and potential risk factors. Dyn Med, 2008, 7: 9. [Medline] [CrossRef]
6) Amis AA: Current concepts on anatomy and biomechanics of patellar stability. Sports Med Arthrosc, 2007, 15: 48–56. [Medline] [CrossRef]
7) Nijs J, Van Geel C, Van der auwera C, et al.: Diagnostic value of five clinical tests in patellofemoral pain syndrome. Man Ther, 2006, 11: 69–77. [Medline] [CrossRef]
8) Solomon DH, Simel DL, Bates DW, et al.: The rational clinical examination. Does this patient have a torn meniscus or ligament of the knee? Value of the physical examination. JAMA, 2001, 286: 1610–1620. [Medline] [CrossRef]
9) Sell KE, Verity TM, Worrell TW, et al.: Two measurement techniques for assessing subtalar joint position: a reliability study. J Orthop Sports Phys Ther, 1994, 19: 162–167. [Medline] [CrossRef]
10) White LC, Dolphin P, Dixon J: Hamstring length in patellofemoral pain syndrome. Physiotherapy, 2009, 95: 24–28. [Medline] [CrossRef]
11) Hirokawa S: Three-dimensional mathematical model analysis of the patellofemoral joint. J Biomech, 1991, 24: 659–671. [Medline]
12) Sanchis-Alfonso V, Roselló-Sastre E, Revert F, et al.: Histologic retinacular changes associated with ischemia in painful patellofemoral malalignment. Orthopedics, 2005, 28: 593–599. [Medline]
13) Witvrouw E, Bellemans J, Lysens R, et al.: Intrinsic risk factors for the development of patellar tendinitis in an athletic population. A two-year prospective study. Am J Sports Med, 2001, 29: 190–195. [Medline]
14) Piva SR, Goodnite EA, Childs JD: Strength around the hip and flexibility of soft tissues in individuals with and without patellofemoral pain syndrome. J Orthop Sports Phys Ther, 2005, 35: 793–801. [Medline] [CrossRef]
15) Powers CM: The influence of altered lower-extremity kinematics on patellofemoral joint dysfunction: a theoretical perspective. J Orthop Sports Phys Ther, 2003, 33: 639–646. [Medline] [CrossRef]
16) Henche HR, Künzi HU, Morscher E: The areas of contact pressure in the patello-femoral joint. Int Orthop, 1981, 4: 279–281. [Medline]
17) Lynn PM: Clinical Assessment Procedures in Physical Therapy. J.B. Sippincott, 1990, p 52 p 326.
18) Levinger P, Gilleard WL, Sprogis K: Frontal plane motion of the rearfoot during a one-leg squat in individuals with patellofemoral pain syndrome. J Am Podiatr Med Assoc, 2006, 96: 96–101. [Medline]
19) Witvrouw E, Sneyers C, Lysens R, et al.: Reflex response times of vastus medialis oblique and vastus lateralis in normal subjects and in subjects with patellofemoral pain syndrome. J Orthop Sports Phys Ther, 1996, 24: 160–165. [Medline] [CrossRef]
20) Huberti HH, Hayes WC: Patellofemoral contact pressures. The influence of q-angle and tendofemoral contact. J Bone Joint Surg Am, 1984, 66: 715–724. [Medline]
21) Fung DT, Zhang LQ: Modeling of ACL impingement against the intercondylar notch. Clin Biomech (Bristol, Avon), 2003, 18: 933–941. [Medline] [CrossRef]