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The role of core endurance and proprioception on knee functionality in patients with patellofemoral pain syndrome

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ABSTRACT

Aim: Patellofemoral pain (PFP) is one of the most common musculoskeletal diagnoses which is considered to be a complex and multifactorial problem. We aimed to determine how the deficiencies in body/core muscle strength and proprioception may affect PFP development.

Material and Method: Fifty patients with diffuse anterior knee pain and/or diagnosed with chondromalacia patella in the study group and 50 healthy adults in the control group were included in this prospective cross-sectional study. The patients with knee disorders except for chondromalacia patella, those who had lower extremity and spinal surgery, and/or had physical therapy in the last 3-months were excluded from the study. Active proprioceptive repositioning test and the prone-bridge test and side-bridge tests were used for primarily assessment of core muscles capacity. The knee functionality was evaluated with Kujala's knee score, and physical activity levels were evaluated with the short form of the International Physical Activity Questionnaire.

Results: The mean age, weight, and median of body mass index were higher in the study group while number of active working patients were significantly higher in the control group. ($p=0.041$) The mean of Kujala, Prone-bridge, Side-bridge (right and left) tests were significantly higher in the control group than the study group. ($p=0.012$) The mean Flex-30 test was significantly higher in the study group than control group. ($p=0.037$) In the study group, there were very strong correlations between hyperextension of body and Kujala tests and between hyperextension of body and prone-bridge tests ($p<0.05$) while there was a very strong correlation between hyperextension of body and flex-30 tests in the control group. ($p<0.05$)

Conclusion: As our body has a closed kinetic chain system, it is obvious that core musculature has great importance on the knee joint. In the current study, we demonstrated the importance of core musculature both in the sense of motor and sensory, on the functionality of knee joint in PFP.

Keywords: Core, proprioception, endurance, patellofemoral pain

INTRODUCTION

Patellofemoral pain (PFP) is one of the most common musculoskeletal diagnoses, accounting for approximately 9-10% of all musculoskeletal complaints and 20-40% of all knee problems and has a very high incidence up to 2.2% per year (1,2). PFP is a common disease in both athletes and general population, particularly caused by recurrent lower extremity overload (3,4). It is more common in active young and moderate age (15-45 years) patients (5).

Until the 1960s, anterior knee pain was used almost synonymous with patellar chondromalacia. However, chondromalacia is not a diagnosis but a surgical finding that expresses softening and fibrillation of the patellar cartilage surface. Many times these two clinical issues (chondromalacia and PFP) don't arise together (4). Patellofemoral pain, which in the past was believed to be due to patellofemoral malalignment, is now considered to be a complex and multifactorial problem (6,7). The etiology of PFP is not clear despite its high prevalence. Many factors have been implicated in the etiology of PFP such as failure of the extensor mechanism, muscle weaknesses, increased Q angle, increased femoral anteversion, excessive use and overloads of lower extremities, and lateral tilt of the patella (8,9). In addition, it was reported that altered neuromotor control of the muscles of the hip and the other parts of the body also contributed to the

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development of PFP (10). Moreover, Leetun et al. found that decrease in hip and body strength (core stability) may associated with an increased risk of knee injury (11). In our study it is hypothesised that there may be an association between core endurance, proprioception, and functionality of the knee. As a result it is assumed that the knee joint may become more functional via sensory awareness owing to endurance and proprioception.

In this study, we aim to examine whether the deficiencies in body/core muscle strength and proprioception may be associated with PFP development.

MATERIAL AND METHOD

This study was performed in the Department of Orthopedics and Traumatology in Kırıkkale University Hospital between December 2018 and December 2020 with the approval of the Kırıkkale University Clinical Trials Ethics Committee under Decision No. 20/02 and dated 27.11.2018. All participants signed a written informed consent form. Patients, between 20-55 years old suffering for diffuse anterior knee pain for at least 8 weeks and/or diagnosed with chondromalacia patella (MRI findings) and/or retro-patellar pain with (during) at least two activities (such as long sitting, stair descending and climbing, squat, jogging, kneeling and bouncing) were included in this prospective cross-sectional study. Totally 137 patients were evaluated and 100 patients were included into our study following the exclusion of patients having the criteria of exclusion (n=37). Control group (n=50) consisted of healthy adults aged between 20-55 years. Patients with localized patellofemoral pain were included in the study group (n=50). The patients with knee disorders except for chondromalacia patella, those who had lower extremity and spinal surgery, and/or had physical therapy in the last 3 months were excluded from the study (n=27). In addition, the presence of neurocognitive deficits, low back pain at 50 mm or over according to the visual analog scale (VAS), and the shoulder pathology's presence hindering to the prone bridge and side bridge tests were determined as exclusion criteria (n=0). 10 patients who refused to participate in our study were excluded also. We chose all patients in order of admittance and all symptoms were evaluated by an orthopedic surgeon whereas all measurements were done by a physiotherapist who was blinded to patients. Power analysis was applied to the normally distributed study parameters using G-Power 3.1 software and it was concluded that the number of patients included in the study formed a sufficient sample (effect size d=1.30, power=0.956, minimum sample size for each group=14).

Evaluation of Body/Core Muscle Strength and Proprioception

A baseline digital goniometer was used for the measurement of the position of the body. Active proprioceptive repositioning test was performed at 30° and 60° of body flexion, 15° of lateral body flexion, and 15° of hyperextension of body (**Figure 1**). These tests were repeated twice after the patients were informed about exact positions of body parts with their eyes closed. Each angle was evaluated randomly three times, and the average of these three measurements was taken to eliminate the risk of learning the evaluation method by the patients . The prone-bridge test was used primarily for the anterior and posterior core muscles and the side-bridge test (right and left) was used for lateral core muscle capacity (12) (**Figure 2**). The functionality of the knee was evaluated with Kujala's knee score and physical activity levels were evaluated with the short form of the International Physical Activity Questionnaire (IPAQ) (13,14). Primary examinations and patient selection were done by an orthopedic surgeon whereas all measurements and scorings were done and recorded by a blinded physiotherapist.

Figure 1. The forward and lateral body proprioceptive repositioning tests

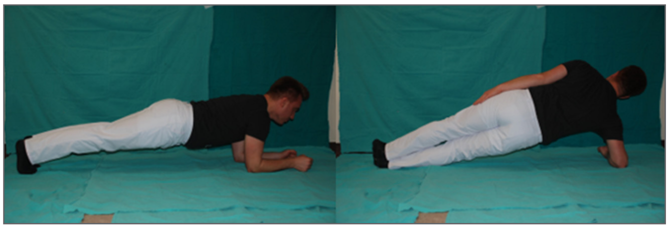

Figure 2. The prone-bridge and side-bridge tests (endurance-strength)

Statistical Analysis

The Statistical Package for the Social Sciences (SPSS for Windows Release 23.0 Standard Version Copyright SPSS, Illinois, USA) program was used for statistical analysis. Descriptive statistics related to categorical variables are given as number and percentage, and those associated with numerical variables were given as mean, standard deviation, median, minimum and maximum. The chi-square or Fisher's exact test was used to compare groups in terms of the qualitative variables. The Shapiro-Wilk test was used to determine whether the numerical variables fit into the normal distribution. Independent groups t-test was used for normally distributed variables, and Mann Whitney U test was used for non-normally distributed variables. Spearman test was used to calculate correlation coefficients and their significance for the association between numerical variables. A significance level of 0.05 was used, p<0.05 was accepted as statistically significant.

RESULTS

A significant difference was found between the groups in terms of age, working status, weight and body mass index (BMI) (p=0.003, p=0.041, p=0.004, p<0.001, respectively). The mean age, weight, and median of BMI were higher in the study group while the number of working patients was significantly higher in the control group. Demographic characteristics of groups were given in **Table 1**.

The mean of Kujala, Prone-bridge, Side-bridge (right) and Side-bridge (left) tests were significantly higher in the control group than the study group. These differences of Kujala, prone-bridge, side-bridge (right), and side-bridge (left) were statistically significant (p<0.001, p=0.012, p=0.004, p<0.001, respectively). The mean of Flex-30 test was significantly higher in the study group than control group (p=0.037). The mean IPAQ was 928.5 in the study group and 1233 in the control group. The difference was not statistically significant (p=0.128) The clinical test results of the groups were presented in **Table 2**.

In the study group, there were very strong correlation between hyperextension and Kujala tests and between hyperextension and prone-bridge tests. In addition, there were strong correlation between flex-30 and Kujala tests and between flex-30 and prone-bridge tests. In the control group, there was a very strong correlation between hyperextension and flex-30 tests. Besides, there were some strong correlations as follows; between hyperextension test and age, between hyperextension and flex-30 tests, between prone bridge and kujala tests, between flex-30 and prone bridge tests, between lateral flexion (right) and prone bridge tests, and between lateral flexion (left) and prone bridge tests. Details of correlations between clinical tests are given in **Table 3**.

Table 1. Demographics characteristics of groups.

Variables	Groups		Test statistics	p
	Patients (n=50)	Control (n=50)		
Age	41 (20-63)	30.5 (21-66)	Z =-2.987	**0.003**
Gender (male)	15 (30)	15 (30)	χ2 = 0.000	1.000
Working status (running)	15 (30)	25 (50)	χ2 = 4.167	**0.041**
Size	1.64 ± 0.10	1.66 ± 0.09	t = -1.368	0.175
Weight	79 (55-130)	70 (48-103)	Z =-2.918	**0.004**
BMI	28.2 (18.6-48.3)	24.91 (18.06-34.66)	Z =-3.668	**<0.001**
Dominant side (right)	47 (94)	49 (98)	-	0.617
Training (yes)	13 (26)	6 (12)	χ2 = 3.184	0.074
Training time (min)	0 (0-14)	0 (0-6)	Z =-1.833	0.067

Table 2. Clinical test results of participants.

Variables	Groups		Test statistics	p
	Patients (n=50)	Control (n=50)		
Complaint duration (months)	12 (1-96)	-	-	-
IPAQ	928.5 (0-12159)	1233 (330- 22302)	Z =-1.520	0.128
Kujala	68.5 (37- 98)	100 (72- 100)	Z =-8.253	**<0.001**
Prone	10 (0- 102)	29.5 (0- 112)	Z =-2.500	**0.012**
Side bridge (right)	6.15 (0- 65)	23.5 (0- 60)	Z =-2.887	**0.004**
Side bridge (left)	6.8 (0- 55)	21 (0- 57)	Z =-3.601	**<0.001**
Flex-30°	6.8 (0.6- 29.3)	4.9 (1- 20.7)	Z =-2.090	**0.037**
Flex-60°	5.2 (0.3- 26.6)	5.9 (1- 38)	Z =-0.021	0.983
Hyperextension	2.85 (0.8- 15)	2.7 (0.3- 6.3)	Z =-0.276	0.782
Lateral flexion (right)	3.165 (0.8- 13)	2.7 (0.7- 11)	Z =-0.614	0.539
Lateral flexion (left)	2.6 (0.7- 12)	2.68 (0.3- 10)	Z =-0.045	0.964

Table 3. Correlation of tests. Bold values indicate statistically significant values (p<0.05). (Under 0.40 is weak, 0.40-0.59 medium, 0.60-0.89 strong, 0.90 and over is expressed as a very strong correlation.)

Variables	Age	BMI	Complaint Duration (months)	Kujala	Prone	Side bridge (right)	Side bridge (left)	Flex 30°	Flex 60°	Hyper extension	Lateral flexion (right)	Lateral flexion (left)
Study group												
BMI	0.00											
Complaint duration (months)	0.22	**.38**										
Kujala	0.00	0.00	**0.57**									
Prone	0.03	0.00	**0.29**	0.00								
Side-bridge (right)	0.00	0.00	**0.40**	0.00	0.00							
Side-bridge (left)	0.00	0.00	**0.58**	0.00	0.00	0.00						
Flex-30°	**0.55**	0.27	**0.56**	**0.84**	**0.80**	**0.34**	**0.46**					
Flex-60°	**0.30**	0.07	0.05	0.15	0.35	0.07	0.11	0.00				
Hyperextension	0.05	0.10	**0.81**	**0.94**	**0.92**	**0.41**	**0.29**	0.11	**0.69**			
Lateral flexion (right)	0.16	0.02	0.53	0.01	0.00	0.00	0.00	0.17	**0.41**	**0.42**		
Lateral flexion (left)	**0.32**	0.01	**0.59**	0.00	0.06	0.01	0.01	0.05	0.04	**0.38**	0.00	
Control group												
BMI	0.00											
Kujala	0.18	**0.29**	-									
Prone	0.12	0.05	-	**0.73**								
Side-bridge (right)	0.06	0.17	-	0.28	0.00							
Side-bridge (left)	0.13	**0.41**	-	0.19	0.00	0.00						
Flex-30°	0.04	0.22	-	**0.43**	**0.82**	**0.28**	0.22					
Flex-60°	**0.34**	0.34	-	**0.47**	**0.58**	**0.33**	**0.31**	0.01				
Hyperextension	**0.79**	**0.60**	-	**0.35**	**0.56**	**1.00**	**0.59**	**0.93**	0.22			
Lateral flexion (right)	**0.30**	0.18	-	**0.52**	**0.76**	**0.65**	**0.41**	0.12	0.00	0.27	.	
Lateral flexion (left)	**0.64**	0.12	-	**0.77**	0.18	**0.51**	**0.35**	**0.59**	0.08	0.51	0.23	

DISCUSSION

Proprioceptive deficits in the knee joint are commonly reported in knee osteoarthritis (OA) which are usually evaluated with joint repositioning tests (15,16). This is a pioneer study of assessment of core proprioception by active proprioceptive repositioning test via the core endurance evaluation in patients with PFP. One of the main findings of this study was significantly higher proprioception deficiency in the study group. Shanahan et al. (17) reported proprioceptive impairments associated with knee OA. Chronic knee pain due to cognitive load may adversely affect proprioceptive memory. Therefore, memorizing the positions or concentrating on the joint position tests may be affected due to knee pain in patients with PFP, same as in patients with knee OA. The authors underlined that a positive correlation between knee functionality and proprioceptive tests can be expected (17). Similarly, in the current study, there was a strong correlation between knee functionality and proprioceptive tests. In addition, in our study it was demonstrated that individuals in the study group had lower endurance of core muscles and had a deficiency in the proprioceptive cycle. These results may be explained by the dysfunction of mechanoreceptors such as articular receptors in the meniscus secondary to joint disruption and periarticular receptors secondary to decreasing endurance of muscles around the joint (17, 18).

Body core musculature has a major role in transferring forces to distal segments and also maintaining an equilibrium to movement in coordination with all body parts. We aimed to determine the role of dynamic control on trunk and so body stability which will results in lower level of patellofemoral symptoms and pain. Core proprioception has been shown as a factor with a minor effect on knee injuries in athletes. But no association has been investigated between core stability and proprioception of extremities together (19). In our study patellofemoral pain has been found directly related to body core and trunk proprioception deficiencies.

Carvalho-e-Silva et al. (20) showed that, dynamic postural stability has also been found to be defective in PFP. Mainly hip abductors and proximal thigh muscles have been evaluated to explain PFP. In recent studies mainly lower extremity kinematics including hip and knee joints have been focused on research of PFP etiology (21-23). We studied not only distal muscle groups and also trunk stabilization in our work. In PFP study group proximal stabilizators of trunk and core musculature were weaker than healthy control group by means of endurance. Decreased muscular endurance of knee extensors and flexors have also been showed to have a role in progression of PFP (24). Decrease in endurance of core muscles seems also to cause in early fail of body stability and so resulting in lower extremity imbalance.

In another investigation of trunk and lower extremity segment kinematics, hip adduction has been found to decrease dynamic knee valgus (25). Although pelvis and hip stabilization is essential for maintaining knee position in squatting, the endurance and proprioception of trunk muscles have not been studied in that manner. We found that not only pelvis and hip stabilization and also core stabilization and its endurance must be maintained in a balanced patellofemoral joint motion.

We demonstrated strong correlation between functionality of knee and core endurance, and proprioception in patients with PFP. According to the findings, low core muscle endurance is an important factor for patients with PFP which results in decreased knee functionality. In addition, the findings of the current study support that further investigation for local proprioceptive deficit related to joint repositioning in PFP is needed. This initial study would be strengthened by further investigations including additional studies about the role of proprioceptive deficits in the worsening process of PFP.

There are some limitations that need to be considered when interpreting the results of this study. These can be summarized as follows: Proprioceptive deficit could be measured via advanced types of equipment such as Cybex and/or Biodex which would allow making more objective measurements. In this study, time-dependent performance tests were performed, but core muscle strength tests could also be measured. In addition, the study could be planned as a multicenter study with larger size sample, methodologically.

CONCLUSION

The mechanical and physiological effects of proximal components on distal segments have been accepted by clinicians for many years in the field of orthopedic rehabilitation. Knee is one of these distal segments. Nevertheless, core muscles of the trunk haven't gained importance as much as the hip. As our body has a closed kinetic chain system, it is obvious that core musculature has great importance on the knee joint. In the current study, we demonstrated the importance of core musculature both in the sense of motor (endurance) and sensory (proprioception) on the functionality of knee joint in PFP.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Kırıkkale University Clinical Researches Etics Committee (Date: 27.11.2018, Decision No: 20/02).

Informed Consent: All patients signed the free and informed consent form.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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