Med. J. Cairo Univ., Vol. 87, No. 4, June: 2409-2415, 2019
www.medicaljournalofcairouniversity.net

Effect of Different Knee Angles on Active Joint Position Sense in Patients with Patellofemoral Pain Syndrome

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Abstract

Background: Patellofemoral pain syndrome is a common, painful musculoskeletal condition that affects physically active young adults and adolescents. During assessment of joint position sense, the different positions of the knee may affect the internal structures of the knee differently. Therefore, examining the differences in the two positions between both males and females may shed light on the effect of muscle activation.

Aim of Study: To examine the differences between 20 and 60 angles of knee extension on knee joint position sense as well as to examine the differences in knee joint position sense between males and females in patient with patellofemoral pain syndrome.

Material and Methods: Thirty nine participants (11 men, 28 women) participated in this study. With a mean age of 18 to 35 years with mean age (24.25±3.40) years, mean weight (68.71±16.01) Kg, and mean height (164.07±10. 14) cm. All subjects were assessed by the same examiner via the Isokinetic Dynamometer Device (IKD) at angles 20º and 60º with angular velocity 2º/sec to determine which angle has more angular error.

Results: The results revealed that the 20 angle position had a significantly greater absolute reposition error than the 60 angle position (p=0.039). There was no significant difference in joint position sense between males and females at angle 20 (p=0.829), and angle 60 (p=0.833).

Conclusion: The results indicate that there is a significant difference in knee joint position sense between position of 20 degrees of extension and 60 degrees of extension. Specifically, as the knee becomes more extended proprioceptive acuity was heightened. Therefore, future research is still needed to discern exactly whether the heightened proprioceptive acuity comes from the differences in gravitational torque or the differences in the anatomical structures of the knee between the two positions.

Key Words: *Patellofemoralpain – Joint position sense – Isokinetic dynamometer.*

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Introduction

ONE of the most common painful musculoskeletal conditions is Patellofemoral Pain Syndrome (PFPS) that affect active young adults and adolescent **[1]**. PFPS common symptom is anterior knee pain that occurs as a result of activity and can be aggravated because of activities that increase patellofemoral compressive forces like climbing and descending the stairs, squatting, and sitting for long periods of time **[2]**.

Tracking of the patella affects the magnitude and the distribution of forces acting at the patellofemoral joint and ultimately patellofemoral joint pressures **[1]**. Proprioceptive information that arises from the active (muscular) and passive (osseous/ligamentous) systems contribute to the overall neuromuscular control of patellar tracking **[1]**.

Balanced forces acting on the patella are required for proper tracking. Too large or too small forces may alter the movement of the patella and results in placing additional stresses on the soft tissue of the joint. Pain response is affected as altered stresses in the cartilage occur; this happens by transferring stresses into the underlying subchondral bone thus exciting nociceptors **[3]**.

Joint proprioception is the awareness of where the joint is in space with regards to both body and mobile segment. Accurate proprioception is critical for proper muscle contraction, limb movement, stability, and injury prevention **[4-6]**. Proprioception is usually looked at in two ways: Joint position sense and the ability to detect joint and limb movement. However, both are essential for fluid muscle contraction, movement and injury prevention.

The proprioceptive mechanism is essential for proper function of the joint in sports, activities of

daily living, and for some occupational tasks [7]. Abnormal proprioception could predispose one to musculoskeletal pathology by altering the control of movement, leading to abnormal stresses on tissues. Alternatively, pathology and pain may alter proprioceptive information, further compounding functional deficits [7]. The knee is subjected to conditions; in which increased torque is placed upon the joint, proprioceptive acuity will increase [8]. Furthermore, as the knee gets closer to its end range of motion proprioceptive awareness will increase [9]. These factors may be important when examining knee proprioception across a variety of movements.

Knee Joint Position Sense (JPS) measurements are often used by clinicians to assess static knee proprioception ability [10]. This is an important measurement for either identifying patients with JPS deficiency that may lead to an increased risk of knee injury or making progress along with proprioceptive based rehabilitation program [10].

Furthermore, the difference in joint proprioception between genders is important to consider. Differences between muscle activation patterns, as well as anthropometric and anatomical characteristics are well noted and hypothesized to illicit changes in injury risk and motor control between the two sexes [11,12]. Specifically, females have significantly less pre-activation of their hamstring than males during cutting maneuvers which may contribute to decreased joint stability [11]. Furthermore, females have also been shown to exhibit less cartilage surrounding their knee when compared to males as well as differences to their intercondylar notch structure [13,14]. These differences may have a profound effect on individual knee joint proprioception. It has been documented that there is a difference in the ability to detect passive movement between males and females [12,15].

However, the presence of this difference is not always expressed when examining the ability to detect passive movement [16]. Examining the difference in Joint Position Sense (JPS) between the two genders may provide more information on their proprioceptive differences.

However, due to the nature of the test, the knee positions may also be affected differently by gravitational torque, and therefore may exhibit differences in muscle activation and proprioception [17,18]. Furthermore, the different positions may affect the internal structures of the knee differently. Therefore, examining the differences in the two positions between both males and females may shed light on the effect of muscle activation, knee angle position, and gender on knee JPS. It is important to test accuracy of proprioception across this variable range of motion.

The aims of this study was to examine the differences between 20 and 60 degrees of knee extension on knee joint position sense as well as to examine the differences in knee joint position sense between males and females in affected leg of patient with PFPS.

Material and Methods

This study was conducted at isokinetic laboratory, Faculty of Physical Therapy, Cairo University from April 2018 to November 2018.

Subjects:

A total of 55 patients were assessed for eligibility criteria. From them, 16 patients were excluded. Patients were excluded because they did not meet the inclusion criteria of this study (n=6), refused to participate in this study (n=10). A total of 39 (28 females and 11 males) participants entered the studywith age ranged from eighteen to thirty five years with mean age (24.25 ±3.40) years, mean weight (68.71 ± 16.01) Kg, and mean height (164.07 ± 10.14) cm; the dominance of females in the sample is typical of the population of people with PFPS. Patients were consecutively recruited from those referred by a physician for physiotherapy because of PFPS Fig. (1).

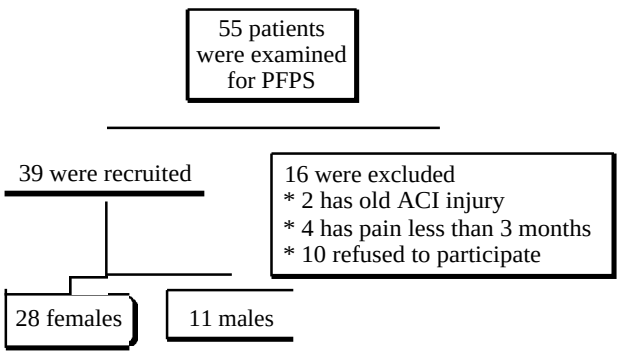

Fig. (1): Participants flow diagram.

Patients included in the study were required to have anterior or retropatellar knee pain from at least 2 of the following activities: (1) Prolonged sitting; (2) Stair climbing; (3) Squatting; (4) Running; (5) Kneeling; (6) Hopping/jumping; (7) Kneel sitting. Insidious onset of symptoms unrelated to a traumatic incident. Age of the subject 18-35 years to limit the possibility that PFPS over age 35 may have been complicated by arthritic changes, and

also the subjects should have closed epiphyseal growth plates. Patient with chronic PFPS (pain >3 months). Subjects were excluded if they had any intraarticular pathology as cruciate or collaterals or meniscus injuries, any surgery or osteoarthritis in knee joint. A history of traumatic patellar subluxation or dislocation. Previous surgery in the knee, ankle and hip joints.

Procedures:

After our protocol was approved by institutional review board (No: P.TREC/012/002041).

All of the subjects were familiarized with the procedure by explanation, demonstration. Testing procedures were completed in an isolated room; participants wore shorts and removed the sock and shoe from their tested leg **[19]**. All subjects were assessed by the same examiner who had 5 years experience. All subjects were informed by the purpose of the study, and informed consent was obtained.

Active joint position sense measured by Biodex system 3 isokinetic dynamometer (Biodex Medical Systems, Shirley, New York, USA) **[20]**. Isokinetic dynamometer provides an objective, reliable, and safe method **[21]**.

The patient sat on the isokinetic dynamometer chair with the hip and knee flexed to 90 degrees, the axis of rotation for the dynamometer was aligned with axis of the knee joint, and the seat height and position were adjusted for accurate alignment. The knee attachment was adjusted to be 3cm superior to the lateral malleolusthen secured by its strap and all visual cues were eliminated via the blindfolds Fig. (2). Testing positions of 20 degrees and 60 degrees were selected on the isokinetic dynamometer protocol with angular velocity 2^{o}/sec **[10]**. The two test positions were tested in the order of 20 degrees and 60 degrees as the dynamometer protocol does not permit random selection. The researcher asked the participant to move the knee from the starting position to the angle being demonstrated by the dynamometer and then to return the knee to the starting position. The participants were asked to remember each demonstrated position and then return the knee joint to the demonstrated position. The participants indicated the reproduction of the knee angle to the demonstrated position by pressing a switch at the appropriate angle and held the leg in this position for 5 seconds. Three trials of demonstrated and reproduced testing were done at each position and the average absolute error values were obtained **[10]**.

Fig. (2): Measuring joint position sense by isokinetic dynamometer.

Statistical analysis:

Descriptive statistics was used to calculate the means and standard deviations of characteristics of the subjects; age in years, weight in kg, and height in cm. An averageof Absolute Angular Error (AAE) was taken from three trials for each test. Paired *t*-test was conducted for comparison of AAE between 2 positions. Independent samples *t*-test was performed, with sex as a grouping variable. Alpha level was set at $p<0.05$ for all analyses. All statistical analyses were performed with the SPSS software (Ver. 20.0; SPSS, Inc., Chicago, IL, USA).

Results

Comparing the general characteristics of females and males revealed that there was no significance difference between both genders in the mean age ($p=0.57$), but there was significance difference in the mean weight and height ($p<0.05$) (Table 1).

The mean absolute angular errors measured by the isokinetic dynamometer were 6.65 ($\pm$1.76), 5.66 ($\pm$2.7) degrees in the 20 degree and 60 degrees test positions respectively. The mean difference

between both positions was 0.995 degrees. There was significant difference in absolute angular errors between both positions (p=0.039) (Table 2), Fig. (3).

Table (1): Demographic data regarding both male and female participants.

	Female (N=28) Mean (SD)	Male (N=11) Mean (SD)	MD	t-value	p-value
Age	23.6 (2.9)	25.9 (4.1)	–2.3	–1.97	0.57**
Weight	63.3 (12.2)	82.5 (16.87)	–19.13	–3.95	0.000*
Height	159.6 (7.8)	175.4 (5.55)	–15.72	–6.07	0.000*

SD : Standard Deviation. p-value : Probability.
MD : Mean Difference. * : Significant.
t-value : Unpaired t-test. ** : Non-significant.

Table (2): Absolute Angular Error (AAE) in angle 20º and 60º of knee flexion for all participants.

	Angle 20	Angle 60	MD	t-value	p-value
• AAE mean (SD)	6.65 (1.76)	5.66 (2.7)	0.995	2.138	0.039*

AAE : Absolute Angular Error. t-value : Paired t-test.
SD : Standard Deviation. p-value : Probability.
MD : Mean Difference. * : Significant.

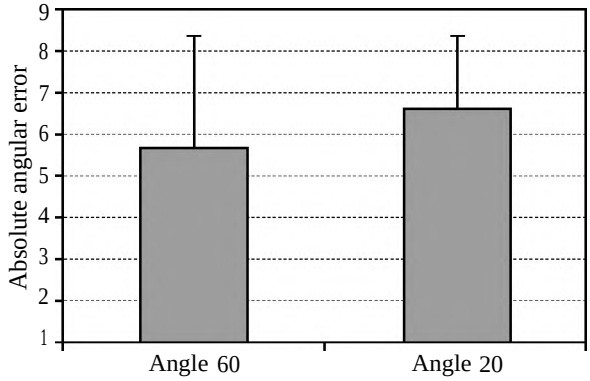

Fig. (3): Absolute Angular Error (AAE) in angle 20º and 60º of knee flexion for all participants.

The mean ± SD of absolute angular error of females and males at angle 20 degrees were 6.69 (1.7) and 6.56 (1.9) respectively. The mean difference was 0. 138 degrees. There was no significant difference in AAE between both genders (p=0.829).

The mean ± SD of absolute angular error of females and males at angle 60 degrees were 5.7 (2.8) and 5.5 (2.6) respectively. The mean difference was 0.2088 degrees. There was no significant difference in AAE between both genders (p=0.833) (Table 3), Fig. (4).

Table (3): Absolute Angular Error (AAE) in angle 20º and 60º of knee flexion regarding both male and female participants.

	Female (N=28) Mean (SD)	Male (N=11) Mean (SD)	MD	t^1-value	p-value	95% CI
Angle 20 degree	6.69 (1.7)	6.56 (1.9)	0.138	0.218	0.829	(–1.148-1.424)
Angle 60 degree	5.7 (2.8)	5.5 (2.6)	0.2088	0.213	0.833	(–1.78-2.198)
MD	0.96	1.05				
t^2-value	1.67	1.39				
p-value	0.107	0.195				

SD : Standard Deviation. t2-value : Paired t-test.
MD : Mean Difference. p-value : Probability.
t1-value : Unpaired t-test. CI : Confidence interval.

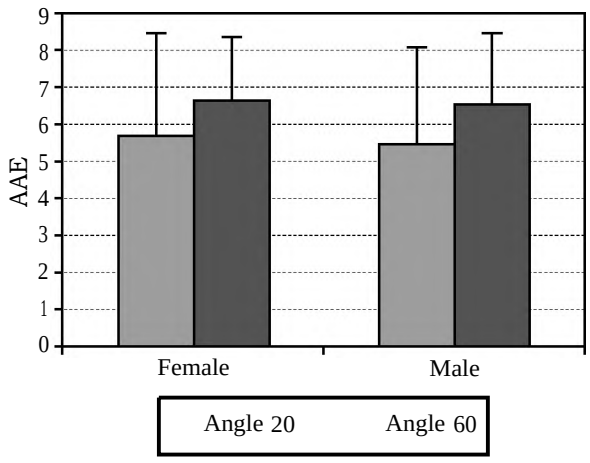

Fig. (4): Absolute Angular Error (AAE) in angle 20º and 60º of knee flexion of both male and female participants.

Discussion

The main purpose of this study was to compare the absolute angular error between outer and inner range in patients with patellofemoral pain syndrome via IKD and also to know whether male or female patients had more absolute angular error regarding each angle.

The study results revealed that absolute angular error for the inner range represented by angle 60º was less than that of the outer range represented by angle 20º for all participants, and this proved that inner range was much better than outer range in patellofemoral pain syndrome patients regarding proprioception acuity (Table 2), Fig. (3), also this

study proved that there's no significant difference between males or females regarding proprioception acuity (Table 3, Fig. 4).

With regards to the differences in joint position sense at different positions of knee extension, according to the results, the 60 degree position had a significantly less absolute reposition error than that of the 20 degree position that agree with work by Lyons **[22]** who found 60º degrees position was significantly more accurate than 30º degree position. Therefore, this study found that as the shank approaches a more extended position, an individual's joint position sense will improve.

There are main differences between the 20 and 60 degree positions tested in this study, firstly, the different positions put different strains on the internal structure of the knee and secondly, the different positions were affected differently by gravitational torque and thus require different levels of muscle activation to maintain **[23]**.

In our test, as the knee became more extended, the moment arm of the shank increased and thus the overall torque demand increased. Therefore, the 60 degree position required a greater torque demand than that of the 20 degree position. It is well documented that as the torque demand on a joint increases there was a potential increase in proprioceptive acuity at that specific joint **[8,24]**. The increase in torque demand will require an increase in muscle activation. With an increase in muscle activation there was an increase in alpha and gamma motor neuron firing frequencies, which maintain the sensitivity of the muscle spindles during the movement **[25]**. Furthermore, the increase in torque demand also increase the tension placed on the surrounding muscles. This increased tension may cause increased sensitivity of the Golgi tendon organs in the muscles which relay proprioceptive feedback **[26]**. Therefore, a potential reason that our study exhibited more accurate JPS at the 60 degree position when compared to the 20 degree position could be due to the increased muscle activation caused by the increase in gravitational torque demanded by the given position.

This study provides valuable information on how gravitational torque and muscle activation can affect the proprioceptive acuity of the knee. However, in order to fully understand how JPS changes at different position within the range of motion of the knee, researchers will first need to accurately account for gravitational torque so that muscle activation does not determine the results.

According to the results of this current study there were no significant differences between the error of males and females during their position reproduction test. Therefore, there may be no difference in proprioceptive acuity of the knee between genders at these positions. These results are in accordance with Pincivero et al., **[16]** that examined the difference in proprioception of the knee between males and females at different knee angles. Specifically, they examined the time to detect passive movement at three different starting positions, corresponding to 15, 30 and 60 degrees of knee flexion. Across all positions there was no difference between males and females.

Findings of present study regarding differences between the error of males and females agree with work Lyons **[22]** that demonstrate there was no significant difference between males and females in JPS and found that 60º degrees position was significantly more accurate than 30º degree position. Although Lyons **[22]** performed a study to test the effect of gender on knee JPS in healthy participants using iPod touch (that was preloaded with a custom JPS software) but in current study IKD was used.

However, to contrast, Nagai et al., **[12]** also examined time to detect passive movement at the knee between genders with motions of internal or external rotation. They found that when moving towards internal rotation, females had a significantly greater time to detect passive movement. It was theorized that this difference was caused by the Anterior Cruciate Ligament (ACL) or surrounding structures Nagai et al., **[12]**. When the knee is rotated into internal rotation, the ACL acts as a secondary restraint. The ligament will stretch and take on a large amount of tension. During this stretch, the change in length and the tension placed on the ligament will cause the capsuloligamentous mechanoreceptors within the ligament to fire and provide proprioceptive feedback **[27]**. It is for this reason that Nagai et al., **[12]** may have found a significant difference between genders. The presented study may not have found any difference in proprioception because our trials may not have rotation.

The inconsistencies in knee proprioception between genders could possibly be attributed to the difference in knee anatomy between the two genders. However, the results found in the present study and in the studies by Pincivero et al., **[16]** and Lyons **[22]** indicate that the difference in knee anatomy may not play a role in proprioceptive

function when performing only flexion or extension of the knee.

Mothersill et al., [28] found that proprioception accuracy didn't differ at angle 20º or 60º of knee flexion in contrast to this present study where angle 60º was much more better than angle 20º regarding to patients' pain where patients in this current study complained of pain and inability to hold their lower limb at angle 20º and that explains why angle 60º was less angular error than angle 20º in this present study. Although IKD was used to assess JPS in patients with PFPS in Mothersill et al., [28] similar to present study.

This study has limitations as the age range, 18-35 year old of the participants has the possibility to limit the findings to other populations. Subjects of varying body size and body type may exhibit different testing effects. Subjects with prior, varying levels of muscular coordination or proprioception may cause a threat to internal validity.

Conclusion:

Based on the findings of this study it can be concluded can conclude that there's no significant difference between males and females patients regarding knee JPS and also that inner range was much better than outer range regarding joint position sense accuracy as it has less absolute angular error.

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المقارنة ما بين مدى الحركة الداخلى والخارجى فى الإحساس المفصلى العميق فى مرضى متلازمة آلم الرضفة

الأهداف وطرق البحث: هدفت الدراسة إلى المقارنة بين مدى الحركة الداخلى والخارجى فى الإحساس المفصلى العميق لمعرفة أيهم أكثر دقة من الآخر فى مرضى متلازمة آلم الرضفة وأيضاً أيهم كان أكثر دقة فى القياس سواء الذكور أم الإناث.

الأشخاص والطريقة: تم مشاركة ٣٩ مشتركاً (١١ ذكور و٢٨ إناث) ممن تتراوح أعمارهم بين ١٨–٣٥ عاماً ويتراوح متوسط الوزن إلى ٨٦.٧١ كجم ومتوسط الطول إلى ١٦٤.٠٧ سم فى هذه الدراسة. وقد تم قياس الإحساس المفصلى العميق لمرضى متلازمة آلم الرضفة عند زاويتى ٢٠° و٦٠° بواسطة جهاز الأيزوكينيتك.

النتائج: تمت المقارنة بين الزاويتين بواسطة حساب معدل خطأ الزاوية لكل زاوية منهم وقد تم إكتشاف أن معدل خطأ زاوية ٢٠ هو ٦.٦٥ ولزاوية ٦٠ هو ٥.٦٦ لكل المشتركين، وقد وجد أيضاً أن معدل خطأ زاوية ٢٠ للذكور كانت ١.٩ وللإناث ١.٧ وأن معدل خطأ زاوية ٦٠ للذكور كانت ٢.٦ وللإناث ٢.٨.

الإستنتاج: ثبت أنه مدى الحركة الداخلى عند زاوية ٦٠ كان أكثر دقة من مدى الحركة الخارجى عند زاوية ٢٠ بخصوص الإحساس المفصلى العميق لمفصل الركبة لمرضى متلازمة آلم الرضفة لكل المشتركين، وقد ثبت أيضاً أنه لا يوجد فرق بين الذكور والإناث بخصوص دقة قياس الإحساس المفصلى العميق لمرضى متلازمة آلم الرضفة.