

Validity and Reliability of Two Methods for Assessing Knee Joint Position Sense in Patients with Patellofemoral Pain Syndrome

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ABSTRACT

Various methods had been used in order to measure the conscious sub modalities of proprioception i.e. Joint Position Sense (JPS), kinesthesia and tension sense. There are several smartphone clinometer applications to assess JPS. Objective: The aim of this study was to determine the validity of “clinometer” software application in comparison to AutoCAD software in assessing knee Range of Motion (ROM) in patients with Patellofemoral Pain Syndrome (PFPS). Patients and Methods: Thirty patients diagnosed with PFPS were 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; and (6) hopping/jumping. Results: The clinometer smartphone application showed excellent Intra-rater reliability in measurement of JPS at 20°; Intra-class Correlation (ICC) was 0.947, with 95% Confidence Interval (CI) 0.903-0.973. The Standard Error of Measurement (SEM) was 0.583 and the smallest detectable change (SDC) was 1.62. Conclusion: The findings of this study demonstrate that the clinometer” application in comparison to AutoCAD software application is a strong criterion validity and intra-rater reliability tool for assessing the knee JPS in patients with PFPS.

Keywords: Patellofemoral Pain Syndrome, Knee Joint Position Sense, Validity, Reliability

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INTRODUCTION

Patellofemoral pain syndrome (PFPS) is a prevalent condition affecting the musculoskeletal system. Its primary symptom is a diffuse anterior knee pain that accompanies activities such as squatting, climbing stairs, and rising from a seated position (Payne et al., 2020).

Patellofemoral Pain Syndrome (PFPS) is a clinical diagnosis that is characterized by an insidious onset of musculoskeletal-related knee pain localized to the anterior retropatellar and/or peripatellar area of the knee (Willy et al., 2019).

It affects the general population, trained athletes, young active adults, and the elderly. Currently, there is no gold standard to clinically diagnose or treat PFPS. Variations in populations assessed, inconsistencies in diagnosis criteria, lack of high-quality evidence on which to base assessment, and lack of any gold standard contribute to the differences reported for incidence and prevalence of PFPS (Smith et al., 2018).

These inconsistencies may be contributed to the varying degree of signs and symptoms each patient presents with. Symptom onset may be traumatic or develop slowly with a worsening of pain during physical activities such as

squatting, sitting with flexed knees, ascending and descending stairs (Colby et al., 2019).

As there is no one specific cause of PFPS, but one of the most commonly accepted hypotheses of the cause of Patellofemoral Pain (PFP) is due to abnormal patellar tracking which increases patellofemoral Joint (PFJ) stress and causes subsequent wear on the articular cartilage. Factors contributing to the cause of knee pain may be direct trauma, faulty patellar tracking, joint degeneration; soft tissue length and strength imbalances in the hip, knee, or ankle/foot; or a combination of factors (Colby et al., 2019).

Proprioception of the knee plays a crucial role in maintaining joint stability and coordination during motion (Romero-Franco et al., 2019). Joint position sense (JPS) is awareness of joint location in space, indicating the accuracy and precision of movement (Nakashima et al., 2021). Proprioceptive sensory impairment may result from neurological disorders (Genoves et al., 2021), chronic soft-tissue diseases (Köprülüoğlu et al., 2022), or neuropathic and orthopaedic conditions (Maras et al., 2021). Joint position reproduction is the most common method of measuring JPS (Hillier, et al., 2015); therefore, it is widely

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used in clinical practice to assess the effectiveness of a rehabilitation program and identify patients at a higher risk of injury (Relph and Herrington, 2015).

Proprioceptive afferents also contribute at the spinal level to arthrokinetic and muscular reflexes, which play a large part in dynamic joint stability. 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 (Hazneci et al., 2005).

Picture capture is also used to gather information regarding knee position as well as JPS of the knee joint. Measurement bias may be introduced to the data because of being the researcher as of part of this data collection. As a result, to remove the researcher bias, smart phone “inclinometer” application is introduced to the study as another method to position the knee joint in its target angle (Relph and Herrington, 2015).

Other studies have reported that motion capture systems or smartphone applications for JPS assessment, may be also valid (Nakashima et al., 2021). Smith et al., 2018 reported good intra-rater reliability for the assessment of JPS using photographs, digital images and replicating knee position using a paper model. However, despite a relatively high number of studies demonstrating the reliability of JPS assessment, the data are often contradictory and inconclusive

An analysis of the validity of JPS techniques is difficult, as there is no universally accepted “gold standard” method of collecting JPS data. However, the use of AutoCAD software to position a limb at a defined angle is accepted (Relph and Herrington, 2015)

The aim of this study was to determine the validity of “inclinometer” application in comparison to AutoCAD software in assessing knee ROM in patients with PFPS.

MATERIAL AND METHODS:

Study design:

The study was designed as a cross-sectional design study. It was approved by the Research Ethical Committee of The Faculty of Physical Therapy, Cairo University (No: P.T.REC/012/003957). A written consent form was obtained from patients before participation in this study.

Participants:

A total number of Thirty patients diagnosed with PFPS were selected according to the following criteria:

Inclusion criteria: 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; and (6) hopping/jumping. 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). **Exclusion criteria:** Meniscal or other intraarticular pathologic conditions; cruciate or collateral ligament involvement, A history of traumatic patellar subluxation or dislocation, Previous surgery in the knee,

ankle and hip joints, Knee, ankle and hip joints osteoarthritis.

Participant Consent

All participants agreed to an informed consent form before the beginning of the study, anonymity and privacy were guaranteed, and all the methods were done consistently with relevant laws and institutional rules.

Instrumentations:

- Bubble inclinometer.
- Digital Video Camera.
- Non reflective markers.
- Tripod.
- AutoCAD software.
- Smart phone application “clinometer.
- Arm band

Outcome measures:

All of the subjects were familiarized with the test procedure by explanation. Testing procedures were completed in an isolated room, participants wore shorts and removed the sock and shoe from their tested leg (Mir et al., 2008).

All subjects were assessed by the same examiner on two occasions two days apart, in order to assess intra-tester reliability and test-retest reliability.

Each subject was sitting at the edge of the table.

The smartphone was attached to the leg above the lateral malleolus. Using the “clinometer” application installed on the smart phone,

The patients were asked to extend his/her leg to the angle of 20 and 60 degrees of knee extension.

Then the patient was blindfolded and was asked to reproduce the same angles again.

The procedure was repeated three times for each angle and the difference between the measures taken with the patient’s eyes open and blindfolded was calculated for the JPS.

For the second method of assessment, the participants were prepared for image-capture data collection by putting four squared markers, each 4 cm in diameter, was attached to their leg at three locations while the subject in this position:

Proximal to a quarter of the distance along a line joining the greater trochanter to the lateral knee joint line, over the neck of the fibula.

over the proximal part of the lateral malleolus. A fourth marker was attached over the iliotibial tract adjacent to the superior border of the patella when the subject in a sitting position (Mir et al., 2008).

A bubble inclinometer instrument was attached to the patient leg at the resting position 90 ° knee flexion to teach the patient how to get the target angles.

The tested leg was passively moved by the researcher to 20° to 60° of knee extension, the participant then actively was holding the leg at each position for 5 seconds. Photographs were taken, while they keep their leg at each position for five seconds (Relph and Herrington, 2015).

A photograph of the leg in the target position was taken using the camera which was positioned 185 cm from the subject and 65 cm from the ground (Mir et al., 2008).

The patient was then blindfolded and the leg was passively returned to the starting angle,
The participant was instructed to actively move that leg to the target angle and hold it in this position and another photograph was taken,
The participant was instructed to move the leg back to the starting position, the process was repeated 3 times for each target angle (Relph and Herrington, 2015).
After completing the procedure for all subjects, the measured angles were assessed via AutoCAD software installed on the computer.

STATISTICAL ANALYSIS:

The degree of correlation of the angles measured via AutoCAD software and clinometer application was measured via Pearson's correlation coefficient.

Intra-rater and test-retest reliabilities were assessed by calculating the intraclass correlation coefficient (ICC). A two-way mixed model effect model and absolute agreement from the SPSS option was used.

The degree of agreement between measurements was also calculated using the Bland-Altman plot.

All statistical analyses were performed using the SPSS statistical version 20.0 with the p-value was set at < 0.05 .

RESULTS:

Correlations of JPS that measured by clinometer smartphone application and AutoCAD software:

Table 1. Correlation between JPS that measured by clinometer smartphone application and AutoCAD software:

JPS (degrees)			R-value	p-value	Sig
At 60°	AutoCAD software	Clinometer smartphone application	00.784	00.001	S
At 20°	AutoCAD software	Clinometer smartphone application	00.793	00.001	S

r value: Pearson correlation coefficient; p value: Probability value; S: Significant

Test-retest reliability of clinometer smartphone application in measurement of JPS:

Table 2. Test-retest reliability of clinometer smartphone application in measurement of JPS at 60° and 20°:

	ICC	(95% CI)		SEM	SDC
		Lower bound	Upper bound		
JPS at 60°	0.973	0.943	0.987	0.363	1.01
JPS at 20°	0.960	0.916	0.981	0.51	1.41

ICC, Intraclass correlation coefficient value; CI, Confidence Interval; SEM, standard error of measurement; SDC, the smallest detectable change.

Intra-rater reliability of clinometer smartphone application for assessing JPS in patients with patellofemoral pain syndrome:

Table 3. Intra-rater reliability of clinometer smartphone application in measurement of JPS at 60° and 20°:

	ICC	(95% CI)		SEM	SDC
		Lower bound	Upper bound		
JPS at 60°	0.949	0.907	0.974	0.271	0.75
JPS at 20°	0.947	0.903	0.973	0.583	1.62

ICC, Intraclass correlation coefficient value; CI, Confidence Interval; SEM, standard error of measurement; SDC, the smallest detectable change.

DISCUSSION:

Because of the importance of proprioception as a key parameter in injury risk and performance monitoring proprioceptive capability has a significant role during both rehabilitation and training (Riva et al., 2005). However, the current instruments to measure this ability are sophisticated and non-portable or involve very labor-intensive measurements to obtain the necessary proprioceptive values (Hillier et al., 2015).

The purpose of this study was to investigate the validity and reliability of clinometer smartphone application for assessing knee JPS in patients with patellofemoral pain syndrome.

Thirty patients with patellofemoral pain syndrome participated in this study. Data obtained from the study group regarding JPS were statistically analyzed.

The results of present study showed that:

The correlation between JPS that measured by clinometer smartphone application and AutoCAD software at 60° was strong positive significant correlation ($r = 0.784$, $p = 0.001$).

The correlation between JPS that measured by clinometer smartphone application and AutoCAD software at 20° was strong positive significant correlation ($r = 0.793$, $p = 0.001$).

The clinometer smartphone application showed excellent test-retest reliability in measurement of JPS at 60°; Intraclass correlation coefficient (ICC) was 0.973, with

95% Confidence Interval (CI) 0.943-0.987. The standard error of measurement (SEM) was 0.363 and the smallest detectable change (SDC).

The clinometer smartphone application showed excellent test-retest reliability in measurement of JPS at 20°; ICC was 0.960, with 95% CI 0.916-0.981. The SEM was 0.51 and the SDC was 1.41.

The clinometer smartphone application showed excellent intra-rater reliability in measurement of JPS at 60°; ICC was 0.949, with 95% CI 0.907-0.974. The SEM was 0.271 and the SDC was 0.75.

The clinometer smartphone application showed excellent Intra-rater reliability in measurement of JPS at 20°; ICC was 0.947, with 95% CI 0.903-0.973. The SEM was 0.583 and the SDC was 1.62.

Previous studies have examined the reliability of digital inclinometer and have reported that they are considered a reliable instrument in measuring active knee JPS and ROM in healthy individuals (Romero-Franco et al., 2019) and (Suner-Keklik et al., 2017).

This study found the inclinometer and AutoCAD to be a valid tool and it also showed high levels of intratester and intertester reliability. In addition, a very high validity has been supported for our proposed inclinometer method by a low SEM compared with video analysis using AutoCAD for knee JPS tasks. Likewise, the inclinometer showed very high intertester reliability and a low SEM during knee JPS tasks.

Findings of the present study regarding the reliability of knee JPS measurements where photography and AutoCAD software were used agree with the results of (Nasseri et al., 2007; Mir et al., 2008 and Fouladi et al., 2012) and this proved that it's a reliable method where ICC was 1, 0.99, 0.99 respectively and these indicate excellent reliability in these studies. This difference may be due to doing the study on healthy participants Nasseri et al., 2007 where they had good proprioception not on PFPS patients who complained from poor proprioception as in current study, also difference in reliability between the current study and (Mir et al., 2008 and Fouladi et al., 2012) studies may be due different positions used in studies as standing weight bearing position was used not sitting position as in current study.

Olsson et al. (2004) performed a study to test the reliability of knee JPS in sitting and prone position using electro-goniometer and proved to be reliable method. Therefore, based on the results of this current study, a system of digital photography, non-reflective markers and AutoCAD analysis is a reliable and precise method to measure the joint angles. This method can be used in laboratory investigations and also in clinical environments to evaluate the JPS. In addition, the present method is objective, less expensive, fast and simple in comparison to other methods.

Studies that evaluated the effects of fatigue on proprioception reported impairments in the acuity of athletes during knee JPS tasks. Romero-Franco et al. (2015) evaluated the effects of a high-intensity anaerobic session as a fatigue protocol for knee JPS and found increases in the AAE during JPS after the fatigue protocol.

Similarly, Bottoni et al. (2015) described the effects of a "hiking fatigue protocol" on the knee JPS in sportswomen. After a fatigue protocol consisting of 30 minutes of uphill walking, the knee JPS of the subjects was impaired. Due to the effect of fatigue on proprioception, previous studies have shown the role of knee JPS in injury risk.

Despite the lack of prospective studies, some authors tried to associate knee JPS with common knee injuries including damage to the ACL. Mir et al. (2014) compared JPS in a neutral knee valgus/toes position in healthy subjects, reporting significantly worse values in the latter relative to the former position in JPS. They suggested that imbalances associated with proprioception in this "risky" position may be related to increased incidence of ACL injury.

Mohammadi et al. (2013) prospectively evaluated the effects of military exercises on JPS in injured and non-injured subjects. All subjects did a specific 8-week training for lower-limb injury and JPS. Those authors reported significantly greater changes in proprioceptive acuity after a fatiguing exercise condition in those who became injured than those who remained injury free.

Likewise, Lee et al. (2015) evaluated knee proprioception in subjects with acute and chronic ACL injury, showing a knee JPS impairment in both ACL injury types, although with a higher grade in subjects with chronic ACL injury. They suggest that the damage produced in the mechanoreceptor located in the ACL may decrease knee proprioception. In addition, those authors reported that the longer the elapsed time to recover from the ACL injury, the higher the loss of proprioception, highlighting the importance of prompt rehabilitation. Therefore, JPS monitoring during the rehabilitation process is needed to prevent a higher loss of knee proprioception, which could facilitate new injuries.

Different authors have reported that an inclinometer is a reliable tool. Reddy et al. (2022) demonstrated good reliability for hip JPS using a digital inclinometer in subjects with unilateral hip OA.

Baert et al. (2018) demonstrated good to excellent reliability (intra-rater and inter-rater) of knee JPS tests measured using an analogue inclinometer in asymptomatic and knee OA patients. Another study evaluated the reliability of neutral head and target head reposition sensibility in subjects with and without neck pain using a digital inclinometer and found the tool reliable (Alahmari et al., 2019).

Barrett et al. (2013) showed very good intra rater and inter-rater reliability of measuring spinal curves using an inclinometer. Also, another study concluded that the dial test using a handheld digital inclinometer to determine external rotation can be presented with acceptable reliability in the clinical setting (Krause et al., 2015).

However, Ribeiro et al. (2011) reported low intra-class reliability at 30° of knee flexion due to the repetition of the JPS test on different day. This might be due to proprioception and especially JPS may be influenced by different factors like time of day, fatigue, or climatic conditions.

Irving et al. (2016) compared the reliability of measuring the sense of knee joint position with a goniometer and image capture technique, measured by two examiners in standing position at angles of 20, 40, 75, and 100 degrees. iPad2 was used for taking images, and only one image was taken from each angle, and the participants returned for a second measurement a week later. Their results for the goniometer and image capture technique showed poor to moderate reliability. This result can be related to the long period between two measurements and taking only one picture from an angle (Selfe et al., 2006).

In another study by Relph, the reliability (ICC) of the image capture technique for the knee joint in the sitting and prone positions was reported to be 0.96 by one tester and 0.98 by several testers (Relph and Herrington, 2015). To our knowledge no previous study had assessed the validity of JPS assessment using AutoCAD software in non-athletic patients with proprioception defects in OKC positions.

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Based on the results of this study we can conclude that AutoCAD software is a valid and reliable method to measure JPS

CONCLUSION:

The findings of this study demonstrate that the smartphone clinometer” application in comparison to AutoCAD software application is a strong criterion validity and intra-rater reliability tool for assessing the knee JPS in patients with PFPS. The application showed strong agreement with inclinometer device and provided consistent measurements with minimal error. These findings suggest that smartphone clinometer application may serve as a practical, accessible, and low-cost alternative for clinical assessment of knee JPS. The therapist can evaluate the knee JPS to monitor its changes throughout the rehabilitation programs. This method had high accuracy, a low exam cost, and didn't involve radiation exposure

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