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Validity and Reliability of Smartphone Goniometer for Assessment of Joint Position Sense in Patellofemoral Pain Syndrome

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Abstract:

Objective: To determine validity and reliability of smartphone application [android app clinometer - version 2.4 (16052510)] in assessment of knee joint position sense in individuals with patellofemoral pain syndrome.

Methods: Thirty-two patellofemoral pain syndrome participants (21 males and 11 females with unilateral symptoms with their age 28.15 ± 5.43 years were included in the study. Active joint position sense was measured by isokinetic dynamometer and by smartphone application at two different angles (30˚ and 60˚) of knee flexion and the results were compared to examine the concurrent validity of the smartphone application. Measurements taken by the smartphone were repeated on the same day by another experienced examiner to measure inter-rater reliability. After two days, measurements taken by smartphone were repeated by the main examiner to measure intra-rater reliability.

Results: Smartphone application was valid alternative for isokinetic dynamometer in measuring active knee joint position sense at target angle 60˚ but not at 30˚. There was a good intra-rater reliability of smartphone application at 60˚ and low intra-rater reliability at 30˚. There was moderate and good inter-rater reliability of smartphone application at 30˚ and 60˚ respectively.

Conclusion: Smartphone is valid and reliable alternative for isokinetic dynamometer in measuring active joint position sense in patellofemoral pain syndrome individuals at target angle 60˚ but not valid at 30˚, while having low intra-rater reliability at 30˚.

Keywords: Validity, Reliability, Joint position sense, Patellofemoral pain syndrome, Smartphone application.

1.Introduction:

Patellofemoral pain syndrome (PFPS) is one of the most prevalent orthopedic conditions in orthopedic medicine and sport events and common in adolescents and young adults. It also accounts for about 25% of injuries among runners (1).

PFPS is an anterior knee pain, caused by altered movements of the patella within the trochlear groove, which may be caused by physical and mechanical alteration in the patellofemoral joint (2).

It is related to activities that increase stress on the patellofemoral joint like ascending and descending stairs, kneeling or running (3). So, PFPS is a problem of continued accumulation of stresses on the muscles of the lower extremity (2).

Proprioception is the ability to sense position and movement of different body segments in space, which has a valuable role in controlling acuity of movement, joint stability, coordination, and balance (4). Joint position sense (JPS) is a subgroup of proprioception that tell us about the precision and accuracy of the movement and its association with performance and injuries (5).

The association between pain at the patellofemoral joint and proprioception deficit emerged from the tension and pressure caused by

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patellofemoral joint malalignment, which leads to alteration of proprioceptive information that may lead to rapid patellar instability causing patellofemoral pain (PFP). Also, chronic and atraumatic patellar malposition can lead to peripatellar plexus dysfunction and reduction of proprioceptive function (6).

Evaluation of proprioception can be done using variable instruments including 3D video systems and isokinetic dynamometer. However, these types of tools are less mobile, require difficult and time-consuming tasks to operate and more costly than other methods. Immediate proprioceptive feedback in the field is important as it could help to monitor athletic performance and provide important information that guides clinical decisions regarding the rehabilitation and training sessions. Such immediacy is difficult to be provided by these instruments (5).

Recently there has been an increase in the use of smartphones application in the medical field as a result of the availability of multiple applications which convert the smartphone into a medical instrument. Smartphone health applications allow the use of smartphone sensors (e.g., gyroscope, accelerometer, … etc.) to obtain useful measurements in clinical practice. Smartphone application can provide fast and simple goniometric measurements while not being restricted to a certain place like other complicated instruments (7).

Smartphone application was valid and reliable instrument in measuring active range of motion (ROM) in cervical spine, lumbar spine, shoulder, elbow, knee, and hip joints in healthy individuals (8-13). Smartphone application was also valid and reliable instrument in measuring JPS of knee and ankle joints in healthy individuals (14). To our knowledge, the smartphone application has never been validated for the assessment of active knee JPS in individuals with PFPS. Therefore, this study attempts to validate and examine reliability of this application in examining active knee JPS in individuals with PFPS.

2.Materials and Methods:

Participants:

Ethical approval of this study was obtained from the review board at Faculty of physical therapy, Cairo University before starting the study [No: P.T.REC/012/003071] which followed the guidelines of declaration of Helsinki on the conduct of human research. Individuals approached between May 2021 and July 2021 to participate in this observational study. This study was conducted at the isokinetic lab and outpatient clinic at faculty of physical therapy, Cairo University, Egypt.

The participants were diagnosed and referred to by an orthopedic surgeon. Participants were rejected because they did not match the inclusion criteria of the study (n = 8). A total of 32 (21 males and 11 females) individuals participated in this study, aging from 18 to 35 years with mean age of 28.15 ± 5.43 years, and a mean body mass index (BMI) of 25.28±4.78 kg/m². (**Figure 1**).

Thirty-two PFPS individuals were included in the study (G-power software program revealed 27 patients + 20% of sample size due to the possibility of drop out, the total sample included were 32 patients). Objectives and procedures of the study were illustrated for each participant before the start of the study. An informed written consent form was filled in by each participant.

Individuals participated in this study had anterior or retro-patellar knee pain from more than one of the following activities: (a) up and down stairs; (b) kneeling; (c) squatting; (d) running; (e) prolonged sitting; and (f) hopping or jumping (15), symptomatic for more than one month (16), gradual onset of symptoms without history of trauma (15), and age ranges from 18 to 35 to allow time for epiphyseal plates to grow in adolescence and to avoid the possibility of patellofemoral joint osteoarthritis in older persons (17).

Participants with history of traumatic patellar dislocation or subluxation were excluded (18). Also, they were excluded if they had a past history of hip, knee, or ankle surgeries, osteoarthritis in the knee, ankle or hip joints, injury of cruciate ligaments or menisci (15), or if they had symptoms for less than one month (16).

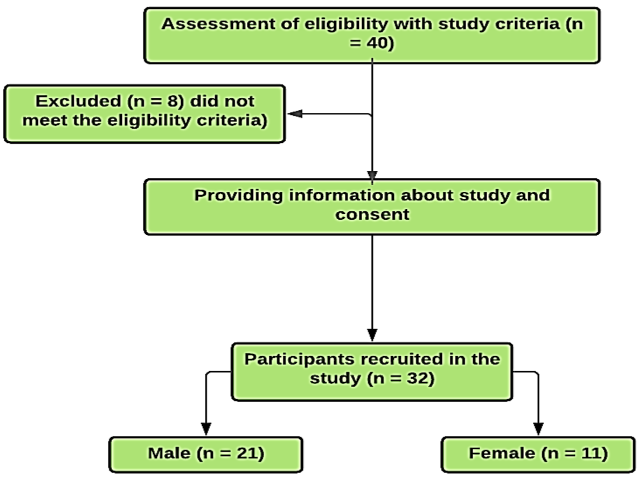

Figure 1. Flowchart of the study.

Procedures:

Study objectives and procedures were explained to each participant before starting the study, and a consent form was filled by each participant. Also, they were informed that data collected would be used for publication. Demographic data was collected from all participants regarding age, height in centimeter, weight in kilogram, and BMI .

Biodex Isokinetic dynamometer (Biodex Medical Systems, 20 Ramsay Road, Shirley New York) and android smartphone (OPPO Reno 5 version 11 android) with Clinometer application [version 2.4 (16052510)] were used for measurements in the study. Testing procedures were completed in the isokinetic lab for isokinetic measurements and in a quite isolated room for smartphone application measurements. Participants put on shorts and took off their shoes from their tested leg (19).

Measurements were taken by 2 examiners (main examiner and research assistant) for each participant. Examiner and research assistant are qualified licensed physical therapists with more than three years of clinical experience and were blinded to results of each other**.**

Knee isokinetic measurements were taken by the main examiner at two different angles (30˚ and 60˚) (20, 21). The participant was seated, and straps were applied around pelvis and thigh of the tested extremity preventing any movement. Eyes mask and ears plug were used to prevent visual and minimize auditory inputs. Then, participant's knee was actively moved to reach the target angle and held for 5 seconds (22), then returned back to the starting position (90˚ of flexion). Then, the participant was asked to close his/her eyes and try to reach the same angle again. This step was repeated 3 times at each angle (23). The mean of the three measures were taken (14). (**Figure 2**).

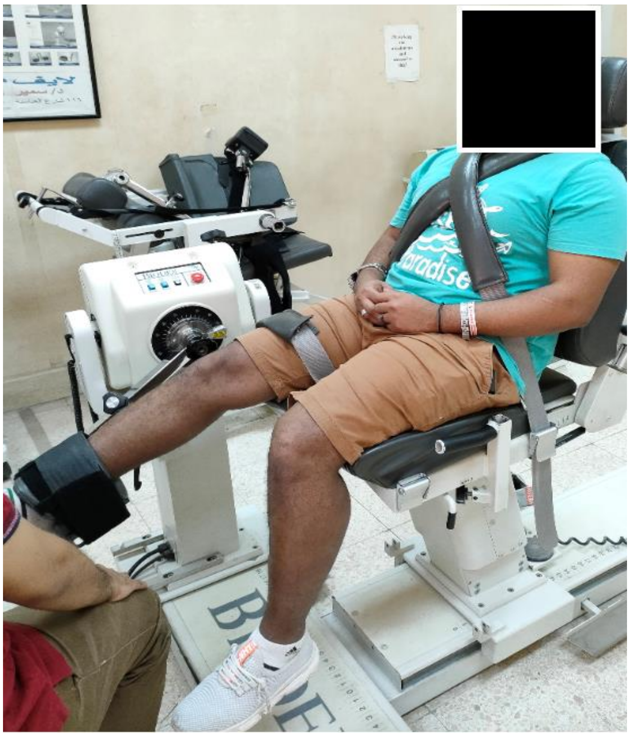

Figure 2: JPS assessment by isokinetic dynamometer.

After isokinetic evaluation, measurements were carried out by the main examiner in the same position with smartphone application. The smartphone was fixed to the middle third of the participant's leg with 2 straps. The same procedure was performed by the smartphone at the two angles (30˚ and 60˚). (**Figure 3**).

Fifteen minutes later (24), the research assistant repeated the smartphone measurements at two angles (30˚ and 60˚). Two days later, the main examiner repeated the smartphone measurements again at two angles (30˚ and 60˚).

Figure 3: JPS assessment by smartphone application

Outcomes:

The main outcome of the current study was the concurrent validity of smartphone application against isokinetic dynamometer in examining active knee JPS at target angle 30˚ and 60˚ of knee flexion in PFPS individuals**.**

The secondary outcome was the intra-rater and inter-rater reliabilities of smartphone application in measuring active knee JPS at target angle 30˚ and 60˚ in PFPS individuals.

Statistical analysis:

Descriptive statistics were carried out for participant's characteristics. Person Product Moment Correlation Coefficient was conducted to determine the correlation between variables to test the concurrent validity of smartphone application in measuring absolute angular error (AAE) at two different target angles (30˚ and 60˚). Inter class correlation coefficient (ICCs) with 95% confidence intervals (CI) was conducted for analysis of intra-rater reliability and inter-rater reliability of smartphone application in measuring AAE at two different target angles (30˚ and 60˚). Level of significance for all statistical tests was set at $p < 0.05$. All statistical analysis was conducted through the statistical package for social studies (SPSS) version 21 for windows (IBM SPSS, Chicago, IL, USA).

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3.Results:

Participant characteristics:

Participant's characteristics are presented (Mean ± SD) in (**Table 1**).

Table 1. Demographic data of all participants:

	Mean ± SD	Minimum	Maximum	Range
Age (years)	28.15 ± 5.43	35	18	17
Weight (kg)	73.74 ± 15.49	47	105	58
Height (cm)	170.41 ± 8.45	154	185	31
BMI (kg/m²⁾	25.28 ±4.78	17	35	18
Affected side, RT/LT	18/14			
Sex, Males/ Females	21/11			

SD: Standard deviation. BMI: Body mass index. RT: Right. LT: Left.

The correlations between AAE measurement at 30° using smartphone application and AAE using isokinetic dynamometer was weak positive non-significant correlation (p = 0.67), (r=0.085). While the correlations between AAE measurement at 60° using smartphone application and AAE using isokinetic dynamometer was strong positive significant correlation (p = 0.000), (r=0.793). (**Table 2**).

In this study, Scatter and Bland-Altman plots were used to test agreements.

Intra-rater reliability of AAE measurement using smartphone application by the same examiner at different times (t1, t2) suggested low reliability for 30° (ICC: -0.095) and good reliability for 60˚. The correlations between AAE measurement at 30° using smartphone application by the same examiner at different times (t1, t2) was negative weak non-significant (p=0.637 (r= -0.095), while the correlations between AAE measurement at 60° using smartphone application by the same examiner at different times (t1, t2) was positive strong significant (p = 0.000) and (r= -0.914). (**Table 3**).

Inter-rater reliability of AAE measurement using smartphone application by two different examiners (smartphone t1, smartphone ex2) suggested moderate reliability for 30° (ICC: 0.695). There was moderate positive significant correlation between AAE measurement at 30° using smartphone application by different examiners (p = 0.000) and (r=0.695). **Table 4.**

Also, Inter-rater reliability of AAE measurement using smartphone application by two different examiners (smartphone t1, smartphone ex2) suggested good reliability for 60° (ICC: 0.899). There was moderate positive significant correlation between AAE measurement at 60° using smartphone application by different examiners (p = 0.000) and (r=0.899). (**Table 4**).

4.Discussion:

Many former studies examined concurrent validity and reliability of smartphone application and concluded that it is a valid and reliable instrument in assessing active ROM in cervical spine, lumbar spine, shoulder, elbow, knee, and hip joints in healthy individuals (8-13).

Also, recent studies conducted by (14, 25), revealed that smartphones are a reliable and valid instrument in examining ankle and knee JPS in healthy active individuals. The purpose of the current study was to examine validity and reliability of smartphone applications among individuals with PFPS.

Physical therapy and rehabilitation require portable, available, cheap, and easily used instruments like smartphone applications to be used in measurement and treatment of different cases (26).

Smartphone became an important instrument that can be used for many purposes including health care and medical purposes. It is usually provided with inbuilt sensors (e.g., accelerometer, gyroscope, or magnetometer) to provide us with measurements useful in clinical practice. Proprioception and ROM can be measured by smartphone if proper applications were installed on smartphone to use its sensors and obtain the desired measurements. Smartphone applications are cheap, fast, portable, and require minimum training, which allows us to obtain measurements anywhere and at any time without restrictions (4, 7, 27, 28).

The purpose of the current study was to examine concurrent validity and reliability of smartphone application against isokinetic dynamometer in measuring active knee JPS at target angle 30˚ and 60 .˚ The current study revealed that smartphone application is a valid instrument in measuring active knee JPS in PFPS individuals at 60˚ compared to isokinetic dynamometer. Unlike other studies (14, 25, 27, 29) which concluded that smartphone applications are valid instruments in measuring active knee JPS, our study concluded that smartphone application is not valid at 30˚ compared to isokinetic dynamometer .

Table 2: Inter class correlation coefficient, Standard Error of Measurement and Minimal Detectable Change values between measurements

	ICC	95% CI		SEM	MDC	p
		Lower Bound	Upper Bound			
Isokinetic vs smartphone main exam. (30˚)	0. 085	0.92	1.69	0.93	1.85	0.67
Isokinetic vs smartphone main exam. (60˚)	0.793	-0.43	0.50	0.54	1.06	0.000*

SEM: Standard Error Measurement. MDC: Minimal Detectable Change.
P value: Probability value.
ICC: Inter class correlation coefficient. CI: Confidence interval.

Table 3: Inter class correlation coefficient, Standard Error of Measurement and Minimal Detectable Change values between measurements

	ICC	95% CI		SEM	MDC	P
		Lower Bound	Upper Bound			
Smartphone main exam. 1 vs Smartphone main exam. 2 (30˚)	-0.095	-0.005	0.72	0.89	1.72	0.64
Smartphone main exam. 1 vs Smartphone main exam. 2 (60˚)	0.914	-.015	0.65	0.25	0.49	0.000*

SEM: Standard Error of Measurement. MDC: Minimal Detectable Change.
P value: Probability value .
ICC: Inter class correlation coefficient. CI: Confidence interval.

Table 4: Inter class correlation coefficient, Standard Error of Measurement and Minimal Detectable Change values between measurements

	ICC	95% CI		SEM	MDC	P
		Lower Bound	Upper Bound			
Smartphone main exam. vs Smartphone assistant (30˚)	0.695	-0.27	0.47	0.52	1.03	0.000*
Smartphone main exam. vs Smartphone assistant (60˚)	0.899	-.084	0.66	0.3	0.59	0.000*

SEM: Standard Error of Measurement. MDC: Minimal Detectable Change.
P value: Probability value .
ICC: Inter class correlation coefficient. CI: Confidence interval.

This may be attributed to the difficulty of actively reproducing the target angle in PFPS individuals due to increased stresses on patellofemoral joint as the participant tries to reach more extended knee positions like 30˚ which lead to higher errors than in more flexed positions (21, 30). Also, muscle weakness and fatigue may lead to inability to accurately reproduce the desired angle during proprioception measurement (31, 32). Moreover, neural activation of quadriceps muscle is decreased when the muscle become in shortened positions (33), making it more difficult to reproduce the target angle 30˚ than 60.˚

Our study also concluded that intra-rater reliability of smartphone application was low at 30˚ but strong at 60˚ of knee flexion, while inter-rater reliability was moderate and good at 30˚ and 60˚ respectively. Previous studies (12, 14, 24, 25, 27, 29, 34) examined reliability of different smartphone applications and reported that they are reliable instruments in measuring active knee JPS and ROM in healthy individuals. This study (14) examined the validity and reliability of an iPhone application (MyProprioception app) in evaluating knee and ankle JPS and ROM in young adults and they found it valid and reliable compared to professional photo-analysis software. Another study (24) assessed validity and reliability of knee goniometer application against standard universal goniometer, and they found no significant differences between them in measuring knee ROM in healthy individuals.

Another study (34) assessed validity and reliability of the smartphone application (Goniometer Records) in comparison to bubble inclinometer in examining knee ROM in PFPS individuals and found it valid and reliable instrument.

Low intra-rater reliability in this study at 30˚ of knee flexion may be caused by conducting the study on PFPS individuals, unlike healthy individuals in other studies, which creates some difficulty in actively reproducing the same target angle due to abnormal stresses on the patellofemoral joint (21, 30). It may also be related to muscle weakness and fatigue which make it difficult to reproduce the desired angle (31, 32). Moreover, the second measurement taken by the main examiner to assess intra-rater reliability was taken two days after the first one, which may cause the results to be different.

To our knowledge, this was the first work to examine validity and reliability of smartphone application in examining active knee JPS in individuals with PFPS.

Limitations of the study:

This study was performed on PFPS individuals within the age of 18 to 35 years, so its results cannot be generalized to PFPS individuals below 18 years old. Also, there was no balance between males and females within the sample (21 males to 11 females). Future studies should consider patients below the age of 18 years and balance between males and females during sample collection.

5.Conclusion:

Smartphone application is a valid and reliable alternative for isokinetic dynamometer in measuring active knee JPS in PFPS individuals at target angle 60˚ but not valid at target angle 30˚, while having low intra-rater reliability at 30˚.

Declaration of interest:

There are no conflicts of interest related to the current work were reported.

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