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Computer-Aided Design Software Measuring Knee Position Sense: A Valid and Reliable Method in Subjects with Patellofemoral Pain

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Abstract:

Purpose: : to evaluate the reliability and validity of computer-aided design (Autocad) software in assessing knee position sense in participants with (PFP) against an isokinetic-dynamometer (IKD) procedure..

Methods: Cross-sectional, validity and reliability study in Isokinetic laboratory**.** Thirty-nine participants (11 males and 28 females) ranging in age from 18 to 35 years old participated in the study. On two separate occasions, two days apart, all subjects were evaluated by the same examiner. Knee joint position sense by isokinetic dynamometer (IKD) and Autocad software at angle 20º and 60º. Intra-tester reliability was obtained by intraclass correlation coefficient (ICC) and standard error of measurement (SEM)..

Results: Validity was determined using the Pearson product-moment relationship, which revealed a moderate to good association (0.60) between the isokinetic dynamometer (IKD) and computer-aided design software at 20º and a good to excellent association (0.79) at 60º. Intrarater reliability coefficients (ICC) were (0.64) at 20º and (0.50) at 60º, indicating a moderate to good association at both angles with a standard error of measurement of (2.2) degree at 20º and (2.9) degree at 60º.

Conclusion: computer-aided design software had high accuracy, a low exam cost, and not involves radiation exposure. These findings support using this method for examining joint position sense. Therefore, Therapist does not need expensive methods to obtain representative JPS abilities.

Key words: patellofemoral pain, position sense, isokinetic dynamometer, Autocad software, validity, reliability.

1.Introduction:

Patellofemoral pain (PFP) is a frequently reported knee pain that affecting active teens and young adults (1). It's characterized by existence of anterior knee pain, (it affects the retro-patellar surface of the patella) which is typically increased by activities that enhance patellofemoral compressive forces, such as descending stairs, squatting, and sitting for long periods (2).

When the stresses exceed the mechanical strength of the tissues, microdamage and pain occur (3).

Changes in cartilage stresses have the ability to influence pain response by transferring stresses into the underlying subchondral bone and triggering nociceptors, and this causes discomfort (3).

Proprioception is required for appropriate joint function in sports, daily activities, and various occupational duties where its afferents contribute to

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arthrokinetic and muscle reflexes at the spinal level, and these have a significant role in dynamic joint stability. Improper proprioception could predispose to pathology by affecting movement control, resulting in abnormal pressures on tissues and altering proprioceptive information, resulting in functional deficiencies (4).

Therapists use knee joint-position-sense to assess static ability of the knee proprioception, which is an essential measure because it can either identify participants who have a JPS deficiency, which may lead to an increased risk of knee injury, or it can help patients progress through a proprioceptive-based rehabilitation program (5).

There is no universally approved method used to collect JPS data. However, it is accepted to use an isokinetic dynamometer (IKD) to place a limb at a specific angle (5).

Various techniques were used, as electrogoniometry, IKD, automated 2D video image computer analysis, kinematic analysis method, visual estimate of the angles measured (e.g., a goniometer, computer monitor or joint model), video and goniometry combined, and photography and goniometry combined (6).

Although instant feedback could assist physiotherapists and athletic trainers in monitoring athletes and making decisions during training and treatment, such immediacy was not accessible for proprioceptive examinations in field situations.

To our knowledge, no previous study had assessed the validity of JPS assessment using AutoCAD software in patients with proprioception defects in OKC positions.

AutoCAD software may be used as a mean of measuring the knee position sense in the patient with PFPS, thus this would provide a valid, costless, and objective mean to measure JPS as well as the isokinetic dynamometer (IKD). Therefore, in this study, concurrent validity was evaluated by comparing a clinical joint position sense assessment using AutoCAD software (computer-aided drafting software method) against an IKD JPS protocol, and to investigate intrarater reliability.

2.Patients and Methods

2.1. Study participants and recruitment criteria:

The study was conducted at Cairo University's Faculty of Physical Therapy's isokinetic laboratory, from September 2018 to February 2019, with registration number (NCT: 03685812).

Participants were consecutively recruited from those referred by a physician for physiotherapy out clinic diagnosed as PFP. Participants included in this study if they have (1)Anterior or retropatellar knee discomfort caused by at least two of the following Activities : (1) sitting for an extended period of time; (2) stair climbing; (3) squatting; (4) running; (5) kneeling; (6) hopping/jumping; (7) kneel sitting. (2) Gradual onset of symptoms unrelated to a traumatic incident. (3)Subjects should be between the ages of 18 and 35 to reduce the probability of PFPS after the age of 35 is worsened by arthritic changes, and they should also have closed epiphyseal growth plates. (4) Patients (nonathletes) with chronic PFPS (pain lasting more than 3 months).

Participants were excluded from study if they had a history of intraarticular pathologic injuries; collateral or cruciate ligament involvement, previous traumatic patellar instability, previous knee, ankle and hip joints surgeries, and ankle, knee and hip joints osteoarthritis.

The sample size was calculated with 80% power and an alpha of 0.05 with r= 0.4232. The value of r was determined based on a pilot study (4 participants) conducted before starting this study to determine the accurate number to participate in the study, which evaluated the relationship between AutoCad and IKD at angle 20̊. Calculations were performed using G*power software [Franz Faul, University of Kiel, Germany], and a sample size of at least 38 patients were identified.

All participants were informed of the aim of the study, and informed consent was obtained. On two separate occasions, two days apart, all subjects were evaluated by the same examiner to assess intra-tester reliability. Three repetitions were performed for each occasion. The mean value of these repetitions was taken.

2.2. Study Design:

This is cross-sectional, validity and reliability study. Ethical approval No: P.T. (No: P.TREC/012/002041) to conduct the research was approved from the ethical committee of Faculty of Physical Therapy, Cairo University, Egypt.

2.3. Methods:

Participants would be prepared to collect image-capture data by placing four 4 cm square markers on their legs at three different positions while lying supine: (1) a quarter of the way down a line from the greater trochanter to the lateral knee joint line, (2) above the neck of the fibula, and (3) Just above of the lateral malleolus. The fourth marker would be placed over the iliotibial tract, at the superior border of the patella, while the person is sitting. (7).

Each participant would seat on the end of plinth and blindfolded via the blindfold (5). Each participant would be instructed to extend his or her leg and make two arbitrary angles from the resting position (90 º) to full extension. The bubble

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inclinometer (Baseline® Bubble Inclinometer, Fabrication Enterprises INC, White Plains, New York 10602, USA) would be attached to the patient leg at the resting position 90 ° knee flexion via the tourniquet. The patient is learned to get angle 20º and 60º via the bubble inclinometer by the examiner.

The tested leg would be assessed for active position sense moved by assessor through 20° to 60° extension of the knee from knee angle of 90° as starting position to a target angle which would be measured by the bubble inclinometer, then the participant held the leg for 5 seconds in this angle (5). Photos would be taken by digital camera (SONY 16.2 MP , 8X optical zoom) and would be analyzed using Autocad software (computer-aided design or computer-aided drafting- manufactured in the Institute of Technology at New York City).

Also, the patient sat on the isokinetic dynamometer (Biodex system 3isokinetic dynamometer, Shirley, New York, USA) chair with the hip and knee in 90 degrees flexion, the dynamometer axis of rotation was aligned with the knee joint axis, and the seat height and position were adjusted for accurate alignment. The knee attachment was adjusted to be 3 cm superior to the lateral malleolus then secured by its strap and all visual cues were eliminated via the blindfolds. On the isokinetic dynamometer protocol, testing positions of 20 degrees and 60 degrees were chosen, with an angular velocity of 2º/sec (5).

Because the dynamometer protocol does not allow for random selection, the two test locations were chosen in the order of 20 degrees and 60 degrees. The assessor instructed the participant to move his or her leg from the starting place to the angle displayed by the dynamometer and then back to the starting place. Participants were asked to recall each demonstrated position and subsequently return the knee joint to that position. Participants indicated the reproduction of the knee angle to the exhibited position by pressing a switch at the proper angle and holding the leg in this position for 5 seconds by pressing a switch at the proper angle. Three trials of presented and reproduced testing were done at each position, and the average absolute error values were collected (5)

3.DATA ANALYSIS:

Descriptive statistics are presented as means and SD for all patients. Then data were t analyzed with according to their statistical distribution using the ShapiroeWilk W test. The association between the IKD and Autocad software on the first day was analyzed using Pearson correlation coefficient, depending on the distribution of data. For correlation coefficients, the strength of association was determined using the following scale: 0.00 to 0.25 indicates little or no association, 0.25 to 0.50 indicates a fair association, 0.50 to 0.75 indicates a moderate to good association and 0.75 and above indicates a good to excellent association (8). Values less than 0.5 indicate low reliability, values between 0.5 and 0.75 suggest moderate reliability, values between 0.75 and 0.9 indicate high reliability, and values greater than 0.90 indicate excellent reliability (8). Using intra-class correlation, we can compare results for between-day reliability (ICC3,1). The standard error of measurement would be calculated for each variable.

SPSS version 20 SPSS version 20 (IBM Inc.,Chicago, IL) was used for all statistical analyses. with the p-value set at ≤ 0.05.

4.RESULTS:

A total of 55 patients were assessed for eligibility criteria. From them, 16 patients were excluded. Patients were excluded because they did not match the inclusion criteria (n=6) or because they declined to participate (n=10).A total of 39 (28 females and 11 males) participants entered the study; the dominance of females in the sample is typical of the population of people with PFPS.(**figure 1**).

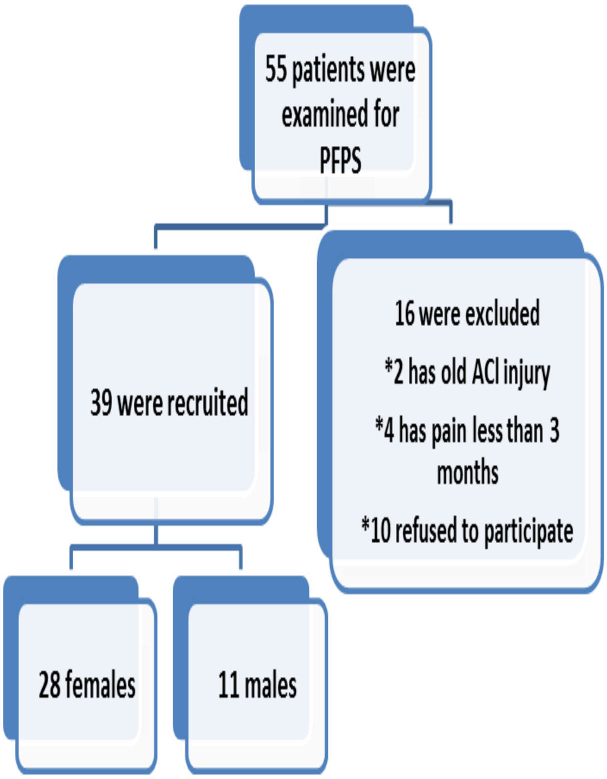

Figure 1: Participants flow diagram.

The mean age was 24.25 (± 3.4) years, weight was 68.71 (± 16.01) kg, height was 164.07 (± 10.14) cm.

Pearson correlation coefficient revealed a good relationship between the isokinetic dynamometer and Autocad software regarding measuring joint position sense at angle 20º ($r = 0.6$, $p<0.05$) and excellent correlation at angle 60º ($r = 0.7$, $p<0.05$). (**Figure2, 3 and Table 1**).

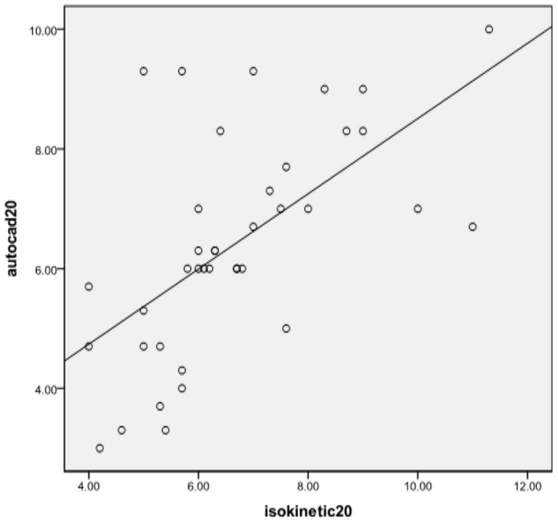

Figure 2: Correlation between Isokinetic dynamometer and Autocad software at angle 20º

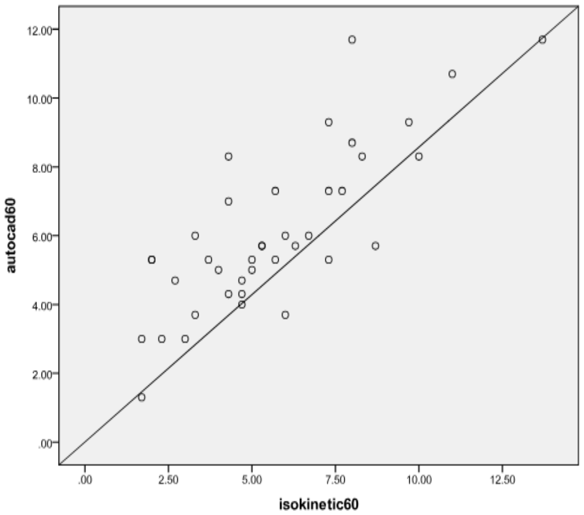

Figure 3: Correlation between Isokinetic dynamometer and Autocad software at angle 60º

Intraclass correlation was calculated for the first and second day image capture at angle 20º (with p-value <0.05) which was equal to (0.647) and revealed that there's moderate relationship between both days with the standard error of measurement (SEM)= 2.21 and angle 60º (with p-value< 0.05) which was equal to (0.515) and revealed that there's moderate relationship between both days with the standard error of measurement (SEM)= 2.98. (**Table 2**).

Table 1: Correlation between Isokinetic dynamometer and AutoCAD software at angle 20º and 60º

	Mean (±SD) (degree)	r	p-value
AutoCAD at angle 20º	6.40 (±1.83)	0.602	0.000
Isokinetic at angle 20º	6.65 (±1.76)		
AutoCAD at angle 60º	6.08 (±2.38)	0.799	0.000
Isokinetic at angle 60º	5.65 (±2.72)		

SD: standard deviation, r: Pearson correlation coefficient, p-value: Probability value

Table 2: Intraclass correlation coefficient (ICC) between first and second image capture at angle 20º and 60º using AutoCAD software.

Intra-tester	**ICC3,1**	**95% confidence interval**	**SEM, deg**	**P-value**
At angle 20º	**0.647**	**(0.42- 0.798)**	**2.21**	**0.000**
At angle 60º	**0.515**	**(0.24- 0.712)**	**2.98**	**0.000**

ICC: intraclass correlation coefficient;
SEM: standard error of the measurement;
deg: degrees.

5.DISCUSSION:

The main aim of this study was to evaluate the validity of AutoCAD software in assessment of JPS in patients with PFP against IKD device. Also, to investigate the reliability of AutoCAD software as the image capture was done two times by the same examiner with one day apart in between.

The study general hypothesis stated that there would be a relationship between AutoCAD software and IKD in assessment of JPS in patients with PFP. The result of this study accepts this general hypothesis.

Based on the findings of current study, we can conclude that Computer-aided design software is a reliable and valid method for measuring joint position sense as well as IKD device.

Results of this current study regarding validity of AutoCAD software in measuring knee JPS agree with(5) who found excellent correlation ($r = 0.7$; $p=0.016$) between AutoCad software and IKD during knee extension which is the same result obtained at angle 60º at this study but only good relation at angle 20 ($r= 0.6$). This difference in validity between both angles in the present study may be due to the inability of the subject to hold their limb at angle 20º and the absolute angular error at this angle is more than at angle 60º.

Findings of the current study regarding the reliability of knee JPS measurements where photography and AutoCad software were used agree with the results of (6, 7, 8) 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 but the present study it showed moderate reliability at both angles of 20º and 60º where ICC= 0.6 and 0.5 respectively.

This difference may be due to doing the study on healthy participants (6) where they had good proprioception, not on PFP patients who complained from poor proprioception as in current study, also difference in reliability between the current study and (7, 9) studies may be due different positions used in studies as standing weight-bearing position was used not sitting position as in current study.

AutoCAD software was also used to analyze lumbar lordosis against a radiographic approach and to verify the reliability of lower limb alignment using a validated landmark method, in (10,11) studies respectively where it showed to be reliable as in current study but it showed excellent reliability in both studies where ICC=0.984 for measuring lumbar lordosis and ICC= 0.977-0.999 for lower limb alignment using landmark method but this present study it showed moderate reliability at both angles of 20º and 60º where ICC= 0.6 and 0.5 respectively. This variation may be attributed to the knee joint having a greater range of motion than the lumbar area.

JPS was tested utilizing a reliable method that included digital imaging, skin markers, and AutoCAD software (12). This method has various advantages, including (1) its utility in weight-bearing, (2) no constraints in joint motion, (3) reduction of inappropriate sensory feedback, and (4) its lack of sophistication and cost.

Kramer et al. (1997)(13) reported moderate intra-rater reliability for patients with PFP (ICC: 0.5 to 0.7) compared to the healthy group when knee JPS was tested for PFP patients against healthy subjects, which agrees with the current study as ICC = 0.6 and 0.5 for angle 20º and 60º respectively.

Photography method using goniometer was used to measure knee ROM against radiological method via (14, 15) and showed to be a reliable method as in this current study but ICC was higher than that obtained in this study where it showed excellent reliability where it varied from 0.98 to 0.998 in both studies.

Lund et al. (2004)(16) used an electrogonimeter to examine the reliability of knee JPS in sitting and prone positions and found it to be a reliable method, but with higher reliability in sitting (ICC= 0.31 to 0.82) and fair to good in prone (ICC= 0.17 to 0.75).

Therefore, according to the findings of present study, a combination of digital photography, non-reflective markers, and AutoCAD analysis provides precise and a reliable method for measuring knee joint position sense. This method used to assess the JPS in investigations as well as clinical settings. In addition, as compared to previous methods, the current method is objective, less expensive, faster, and simpler. It is more critical in this method to measure JPS in one session rather than repetitions with short or lengthy intervals.

There are a few limitations to this study that should be considered in future studies. First, participants of various body size and type may demonstrate varying testing effects. Second, participants with varied levels of muscle coordination or proprioception may risk internal validity.

5.CONCLUSION:

AutoCAD software was highly accurate, had a low exam cost, and did not require radiation exposure. These findings support the use of this method to measure position sense of the knee joint in people suffering from patellofemoral pain.

Conflict of interest:

Authors state no conflict of interest.

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