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Validity and Reliability of Digital Inclinometer for Assessment of Joint Position Sense in Patients with Knee Osteoarthritis

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Abstract:

Background: Knee osteoarthritis is considered the most common chronic degenerative joint disease, impairing the quality of life and function among older adults. Impaired somatosensory and proprioceptive function have been linked to Knee osteoarthritis.

Objective: To examine the validity and reliability of digital inclinometer in measuring knee joint position sense in individuals with knee osteoarthritis.

Methods: Thirty male and female patients diagnosed as knee osteoarthritis participated in this cross-sectional study (their mean of the age was 56.33 ± 4.41; weight was 85.9 ± 12.96; and height was 161.16 ± 9.39 respectively. All participants were examined for active knee repositioning test using digital inclinometer & isokinetic dynamometer to determine absolute angular error for target angle 30 degrees (open kinetic chain).

Results: The results indicated that absolute angular error by digital inclinometer was good positive significantly associated with absolute angular error by isokinetic (p-value=0.001). The inter-class reliability showed that there was a low reliability of absolute angular error by digital inclinometer (with ICC=0.467 and P-value=0.004). The intra-class reliability showed that there was a high reliability of absolute angular error by digital inclinometer (with ICC=0.691 and P-value=0.0001).

Conclusion: Digital inclinometer is a valid alternative for isokinetic dynamometer in measuring active knee joint position sense in individuals with knee osteoarthritis at target angle 30˚ of knee flexion. However, there were high intra-class reliability and low inter-class reliability at target angle 30˚ of knee flexion.

Keywords: Knee osteoarthritis, Reliability, Validity, Joint position sense, Isokinetic, Digital inclinometer

1.Introduction:

Knee osteoarthritis (KOA) is one of the most common age-related diseases featured by cartilage loss and subchondral bone damage. KOA leads to changes not only in tissues within the articular cavity but also in ligaments, tendons, periarticular tissues, and muscles (1,2). Literature shows that KOA patients have significantly worse proprioception than healthy individuals (3,4). Proprioception refers to the body's ability to perceive the sense of joint position and the sense of movement in space (5). It is considered an important factor of neuromuscular performance and

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the basic element of the spontaneous control of movement, coordination, balance, and joint stability for all daily activities (6,7).

Joint position sense (JPS) is a subcomponent of proprioception that informs about the accuracy and precision of the movement and its relationship with performance and injuries (8,9). Literature showed that the degeneration of knee joint proprioception increases as osteoarthritis worsens (10-12). Sensory receptors located in the knee joint components are damaged resulting in the generation of abnormal proprioceptive sensory signals informing the brain on joint position and joint movement in an incorrect manner (10).

There is evidence that KOA patients with severe radiological osteoarthritis have more proprioceptive deficits than patients with minimal symptoms (13). Whether impaired proprioceptive function is a result of KOA, comprehensive assessment of proprioception and follow up are essential while treating KOA (12).

The most common method used to evaluate knee proprioception is the joint position reproduction (JPR) assessment using an isokinetic dynamometer (14). However, its complicated application and non-portable design of isokinetic dynamometers forced researchers to find simple devices to assess JPR. The digital inclinometer was found to be a simple and inexpensive method which could be used for evaluation active knee joint position sense (AKJPS) (15).

Therefore, the cross-sectional study was planned to investigate validity, inter-class reliability, and intra-class reliability of digital inclinometer in assessment of JPS in patients of KOA. Also, the study evaluates the reliability and validity of another type of digital inclinometer (SPI Tronic, Penn tool co, Maplewood, NJ).

2.Materials and Methods:

Participants:

This cross-sectional study was conducted between May 2021 and November 2021. Patients were enrolled from the clinic of outpatient in the faculty of Physical Therapy of Cairo University. Study procedures were completed in laboratory setting at the Biodex Isokinetic Dynamometer laboratory of faculty of Physical Therapy of Cairo University. Thirty volunteer patients (14 males and 16 females), their age ranged between (50-70) diagnosed with KOA, were referred from an orthopedic surgeon with their plain radiographs showing KOA with KL classification grades 2- 3.

Patients were recruited to the study based on the clinical classification standards of American College of Rheumatology (ACR) (16). Patient should have pain in the knee joint plus at minimum 3 of the following clinical findings, age (50-70), complain from joint stiffness at the morning, complain from sensation of crepitation during active motion, bony margins tenderness, bony enlargement noted on examination or lack of palpable warmth of the synovium.

Patients were excluded in case of any history of recent lower extremity surgery, severe trauma in lower limb (e.g., fractures, cartilage disorders, and tears in ligaments), systemic diseases (e.g., rheumatoid arthritis) and other disorders resulting in lower limb complaints (15). Moreover, the exclusion executed in condition of any restriction of range of motion that cause inability of patient to reach to the target angle (30º).

All patients who met the inclusion criteria were asked to sign a consent form to participate in this study. The study was approved by the ethical committee of the faculty of Physical Therapy of Cairo University [No:P.T.REC/012/003302]. Demographic data including age, gender, height, and weight were recorded in the data sheet. JPS was assessed by digital Inclinometer and isokinetic Dynamometer. All patients were assessed twice in the same way and at the same time of the day. There were two days apart between the two assessment times.

Procedures:

Proprioception evaluation was started by using the isokinetic system in measurement of JPS by active joint reproduction test. The JPS testing was conducted in the sitting position without feet floor contact, at a quiet place with closed eyes, then assessing the affected extremities of all participants. Patients sat up at 80° inclination on isokinetic dynamometer chair, and the tested knee was at the same level of the dynamometer axis. The thigh was stabilized with a band. Also, the tibia was stabilized with a band that was superior to the lateral malleolus by 3 cm. The starting position of the test was 90° flexion. The proprioception evaluation angle was defined at 30°.

Participants were asked to extend their tested knee to the target angle of 30° from the initial position (90° knee flexion) then to return to their initial position after 5 seconds in this position. Before each measurement, a familiarization trial was carried out according to the test protocol of Biodex Isokinetic Dynamometer (BID). After this procedure, participants were asked to reproduce the target angle as exactly as possible and reproduced angles were recorded **Figure (1).** This step was repeated three repetitions and the average of the three measurements

was recorded (17). There was adequate rest between each measurement (20 seconds) to avoid fatigue.

Figure 1: JPS assessment by isokinetic dynamometer.

Afterwards, the measurements were implemented by the digital inclinometer in a similar open kinetic chain position. Participants were in a similar position as the test at the isokinetic system, and the digital inclinometer was stabilized to the middle third of the subjects' leg (15 cm distal from the apex of the fibular head) with a strap. Similar to Isokinetic procedure was followed and a familiarization trial was carried out before each measurement (17). (**Figure 2**).

Figure 2: JPS assessment by digital inclinometer

Two different sessions were completed: in the first session, proprioceptive error during the active joint reproduction test reported by the digital inclinometer and by BID were compared to calculate the inclinometer concurrent validity during the JPS test. Also, in the first session, two examiners were blind to the study aims and protocol observed the angles that the digital inclinometer revealed and analyzed the proprioceptive error of all the participants. Results reported by examiners 1 and 2 were compared to determine inter-class reliability.

After two days in the second session, examiner 1 recorded the angles that the digital inclinometer showed and obtained the proprioceptive error. Results reported by examiner 1 in 1st session and those obtained in 2nd session were compared to determine intra-class reliability. Proprioceptive error was absolute angular error (AAE). The degrees deviating from the reference angle then recorded without regard to the direction of error is the AAE. The average of the three successive measurements calculated to be the absolute angular mean (AAM) which used for statistical analysis.

Statistical analysis:

All Statistical analyses were carried out using SPSS version 23.00 software (IBM Corporation, Illinois, USA). Alpha level set at 0.05. Validity and reliability of digital inclinometer in measuring AKJPS in KOA at target angle 30˚ of knee flexion, was compared by the results of the isokinetic dynamometer using Pearson's Correlation Coefficient (r). Correlation values of 0.40 or above were considered satisfactory (r ≥ 0.81–1.0 as excellent, 0.61– 0.80 very good, 0.41–0.60 good, 0.21–0.40 fair, and 0–0.20 poor) (18,19).

Reliability assessment of the AAE by digital inclinometer was calculated by intraclass correlation coefficient (ICC) values for intra and inter-rater reliability. Values of ICC vary from 0 (totally unreliable) to 1 (perfectly reliable) and values ≥ 0.80 were considered as evidence of excellent reliability (20).

3.Results:

Subject characteristics: Thirty participants (16 females, 14 males) diagnosed with primary knee OA participated in this study. Demographic data of the participants presented in (**Table 1**). Validity: The correlations between AAE by digital inclinometer and AAE by isokinetic dynamometer measurement at 30° were positive good significant correlation ($p < 0.05$) (**Table 2**). Intra-class reliability: The intra-class reliability using the (ICC) showed that there was a high reliability of absolute angular error by digital inclinometer (**Table 3**). Inter-class reliability: The inter-class reliability using (ICC) showed that there was a low reliability of absolute angular error by digital inclinometer (**Table 4**).

Table (1): Demographic data of the participants.

N= 30 (16 females, 14 males)			
	Mean ± SD	**Minimum**	**Maximum**
Age (years)	56.33 ± 4.41	50	67
Body mass (Kg)	85.9 ± 12.96	65	115
Height (cm)	161.16 ± 9.39	145	180

Table (2): Concurrent validity analysis using Pearson Correlation Coefficients between absolute angular errors by digital inclinometer and isokinetic dynamometer.

Variables	Absolute angular error by digital inclinometer	Absolute angular error by isokinetic
Mean ± SD	2.41±1.50	2.74±1.71
r	0.561	
p-value	0.001	

r value: Correlation coefficient value - p value: Probability value (p<0.05)

4.Discussion:

The study was conducted to examine the validity and reliability of digital inclinometer in measurement of the AKJPS in KOA at target angle 30˚ of knee flexion. To the knowledge of the authors, no previous research work has been reported in this area specifically**.**

The results of the study showed that joint position sense measurements obtained in the position of open kinetic chain with the knee in 30° flexion in patients with knee osteoarthritis had good validity. Some previous studies assessed the concurrent validity of digital inclinometer, they concluded that it is a valid instrument in measuring active ROM in hip joint (21) and joint position sense in shoulder joint (22). Furthermore, other recent studies revealed that digital inclinometer is a good instrument in measuring knee joint position sense in healthy active individuals when compared to isokinetic dynamometer (17) and video analysis (15).

Table (3): (ICC) for Intra class reliability of absolute angular error by digital inclinometer:

absolute angular error by digital inclinometer		
	1st reading	**2nd reading**
Mean ±SD	2.41±1.5	2.09 ±1.31
ICC	0.691	
P-value	0.0001	

ICC: Inter class correlation coefficient value - p value: Probability value (p<0.05)

However, one study revealed that JPS achieved by the position of open kinetic chain with the knee in 30° flexion in healthy participants had moderate validity (15). This may be due to the weight of the isokinetic dynamometer and or muscle fatigue (23). Furthermore, the requirement to carry the heavy weight dynamometer during the test of active repositioning causes problems in finding the accurate angle, leading to conflicting outcomes in the proprioception evaluation (17). The results of the proprioception examination may be changed by muscle fatigue (24). Muscle fatigue results in change of the muscle spindle activation pattern (25), in addition to decrease the proprioceptive afferent nerve sensitivity (26).

Table (4): (ICC) for Inter class reliability of absolute angular error by digital inclinometer:

absolute angular error by digital inclinometer		
	1st tester	**2nd tester**
Mean ±SD	2.41±1.50	2.03 ±1.42
ICC	0.467	
P-value	0.004	

ICC: Inter class correlation coefficient value - p value: Probability value (p<0.05)

Conversely, the digital inclinometer is light in weight, simple and easy-to-use. It could be used to assess proprioception (17). In the study, the authors have concentrated on the pre-session training on isokinetic dynamometer and there was adequate rest between each measurement on isokinetic dynamometer to avoid fatigue.

Also, contrary to our study, **MOHAMED et al.** (27) revealed that digital inclinometer was not a valid tool in measuring AKJPS in individuals with primary knee osteoarthritis. However, there was no comparison to a 'gold-standard' is a limitation in the study. But in our study, there was comparison between digital inclinometer and isokinetic 'gold-standard' in measurement active knee joint position sense (AKJPS).

Moreover, the study concluded that the intra-class reliability of digital inclinometer was high at 30˚ of knee flexion, while inter-class reliability was relatively low at 30˚ of knee flexion. 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 (15,17).

Different authors have reported that an inclinometer is a reliable tool. **Reddy et al.** (28) demonstrated good reliability for hip JPS using a digital inclinometer in subjects with unilateral hip OA**.**

Baert et al. (29) 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 (30).

Barrett et al. (31) 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 (21).

However, **Ribeiro et al.** (7) reported low intra-class reliability at 30˚ of knee flexion due to the repetition of the JPS test in 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. Therefore, in this study, the authors have considered the same time of day, site and procedures in the second session compared to the first session. In the study, the relatively low inter-class reliability at 30˚ of knee flexion may be due to inadequate rest duration between sessions (session test of concurrent validity of digital inclinometer and the other session test of the inter-class reliability).

5.Conclusion:

Digital inclinometer is a valid tool alternative for isokinetic dynamometer in measuring active knee JPS in OA individuals at target angle 30˚ of knee flexion. However, there were high intra-class reliability and low inter-class reliability at target angle 30˚ of knee flexion. Also, the study revealed that another type of digital inclinometer (SPI Tronic, Penn tool co, Maplewood, NJ) is reliable and valid.

Declaration of interest

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

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