Validity of smartphone use in measuring joint position sense in patients with knee osteoarthritis:A cross-section study.

Basma Osama ALSaadawy[1], Nadia Abdo[1], Eman Embaby[2,]Aliaa Rehan Youssef [1]

[1] Department of Physical Therapy for Musculoskeletal Disorders and Surgery/ Faculty of Physical Therapy/ Cairo University.

[2] Department of Basic Science / Faculty of Physical Therapy/ Cairo University.

Abstract:

Background: Proprioception deficit is a risk factor for knee osteoarthritis(OA) progression. Thus, proper assessment and treatment of this deficit are important in the management of patients with OA. Recently, smartphone has been used in the assessment of musculoskeletal system. There are a few valid applications to measure proprioception of various joints, suggesting the promising use of smartphone as an alternative economic method to assess proprioception acuity in clinical settings. However, validation of proprioception assessment still needs further confirmation. Therefore, this study aimed atinvestigatingthe concurrent validity of using smartphone in assessing proprioception acuityin patients with knee OA.

Methods: Thirty-two knees from 16 participants were assessed; 8 asymptomatic volunteers and 8 patients with bilateral OA. Proprioception acuity was measured in terms of passive joint position (JPS) simultaneously bythe smartphone Goniometer pro application andthe Biodex System 3 Pro Isokinetic Dynamometer. Each participant had the angle of repositioning error measured during passive motion three times and the average was calculated and used for further statistical analyses.

Results: There was a strong positive correlation between smartphone and isokinetic dynamometer measurements of repositioning error angle for participantsin the two study groups.For the non-dominant knee, the correlation was perfect in the OA and asymptomatic groups($r = 1$) ($p < 0.05$). For the dominant knee, the correlation was significant, positive and high for the asymptomatic ($r=0.70$) and OA ($r=0.90$)groups ($p<0.05$).

Conclusion: Smartphone application is a validalternative for the Isokinetic dynamometer in assessing passive JPS in patients with knee OA and asymptomatic controls.

Key words: joint position sense, knee osteoarthritis, smartphone.

- **Introduction:**

Osteoarthritis(OA) is the most common degenerative joint disease affecting all the structures of synovial joints.[1]It is associated with pain,muscle weakness and impaired proprioception acuity.[2,3] OA imposes physical, psychological and socioeconomic burden on patients, their families and the whole community.[1]

Proprioception deficit has been proposed as a risk factor for the development and progression of OA.[3,4]Proprioception is the resultant of kinesthesia and joint position sense (JPS); where kinesthesia is the awareness of movement and JPS is the awareness of limb position in space.[5,6]JPS can be assessed by several instruments such asthe digital inclinometer, electrogoniometer and isokinetic dynamometer.All these instruments are valid, reliable and safe, yet, they are expensive and not available in regular clinical settings and office-based clinics[7,8], especially in economically challenged countries. With the emerging use of smartphone as a tool with built-in accelerometer, magnetometer and gyroscope sensors, it can be used as a clinical assessment tool of joint excursion. Smartphonehas been proven valid to assess range of motion (ROM) and JPS of different body regionssuch as the shoulder, knee and ankle.[9]-[11]However, smartphones have never been validated for the assessment of knee proprioception, particularly JPS, in patients with OA. Thus, this study investigated the concurrentvalidity of using smartphone in assessing JPS in patient with knee OA.

- **Material and method:**

Study design

This is a cross-sectional one-testing session study that was conducted at the Biodex isokinetic laboratory, Faculty of Physical Therapy, Cairo University, Egypt, between November 2018 and January 2019. The study was approved by the local institutional ethics committee (P.T. REC/012/002013).

Participants:

Sixteen participants, 8 asymptomatic volunteers and 8 patients with bilateral OA were enrolled in this study.Asymptomatic subjects aged between 40-60 years old and had no signs or symptoms of lower quadrant dysfunction. Patients with bilateral OA were recruited according to the clinical American College of Rheumatology criteria[12] as follows:age above 40, morning stiffnessfor less than30 minutes, crepitus on active knee movement, bony enlargement either palpable or visible in radiographs and bony tenderness at joint margins. Participants were excluded if they had steroid injectionwithin two months before enrollment,any lower extremity neurological dysfunction, or trauma within the past year or if they reported a history of instability.[13]

- **Testing procedures**

After screening against study inclusion and exclusion criteria,eligible participants were informed verbally about the aim of the study and all testing procedures. Then, they were invited to participate in the study, if they agreed, an informed consent was signed and all relevant demographic information and medical history were collected. Further,the peakcurrent pain severity,as determined by the Visual Analogue Scale (VAS), was recorded.

Each participant had the two knees assessed at a random order generated by excel software random function.During testing, the two devices were simultaneously used for

JPS assessment. Participant's preparation and isokinetic testing were done by the same trained assessor(BA) while a second blind assessor (NA)recorded smartphone data throughout the testing.

Testing set-up:

Each participant sat in the isokinetic dynamometer chair with the trunk positioned at 85º . The seat position was adjusted so that the distance between the edge of the chair and the popliteal fossawas one finger breadth.The dynamometer axis was aligned with the lateral epicondyle of the knee.The transducer cuff of the dynamometer's moving arm was placedthree fingers above the lateral malleolus.[14]A standard smartphone (iPhone 6),with the Goniometer Pro application installed, was secured above the transducer cuff of the dynamometer using an armband.

Initially, knee zero flexion (complete extension) was determined by a standard universal plastic 360° goniometer and fed into the dynamometer software.Then, passive JPS was tested within 5º -25º knee flexion for three times. During the testing, the assessor provided clear instructions on the testing procedures, handed the participant the isokinetic stop-button,and gave standardized commends.Testing started bythe isokinetic dynamometer moving the tested leg passively at 5°/s.[5]The target position was held for 7 sec so thatparticipant could memorizeit, before the machine returned the knee to the initial startingposition. The isokinetic dynamometer then moved the knee again atthe same speed and the participant was asked to press the stop button when he/she felt the predetermined target angle was reached.[5]

Data analysis

The main outcome for this study was the concurrent validity of smartphone measurement of repositioning error angle compared to that obtained by the Isokinetic dynamometer. This angle was calculated as the absolute difference between the targeted and actually reached angles. Three trials were collected for each knee, and the average was calculated and used for statistical analyses.

First, data were screened for normality assumption using Kolmogorov-Smirnov and Shapiro-Wilks normality tests. As data were notnormally distributed, the non-parametric Mann-whitney test wasemployed to compare participants' baseline characteristics. Further, the Spearman rank correlation coefficient (ρ) was used to assessconcurrent validity by studyingthe association between the isokinetic dynamometer and smartphone data of both knees in each tested group. The level of significance was set at $p<0.05$. Correlation results were interpreted as negligible ($r < 0.30$), low ($r = 0.30$ to 0.50), moderate ($r = 0.50$ to 0.70), high ($r = 0.70$ to 0.90), or very high ($r > 0.90$).[15,16]All statistical analyses were done using the SPSS version 18 (IBM Inc., Chicago, IL, USA).

Results:

Sixteen participants were enrolled in this study.The OA group had eight participants with bilateral symptomatic knee; 30% were females and 70% males. The control group consisted of eight asymptomatic participants; 25% were females and 75% were males. For OA group, the mean agewas51.87±6.12 years,and mean BMI was 30.54±7.47 kg/m^2. For the control group, the mean agewas 48±5.63 years, and mean BMI was 30.30±8.64kg/m^2.There were no significant differences in age and BMI between the two groups ($p>0.05$). For peak current perceived pain in the OA group, the mean VASwas 5.9±1.7.

For the non-dominant knee, a perfect positive correlation was found between the angle of repositioning error measured by the isokinetic dynamometer and smartphone application in the two study groups(r=1, P < 0.05). The dominant limb showed a significantly high positive correlation in the asymptomatic (r = 0.70) and OA groups (r=0.90) (P < 0.05) (Table 2).

Table (2): Spearman (ρ) correlation coefficients between the angles of repositioning error measured by isokinetic dynamometer and smartphone in the two study groups

Group	Dominant limb	Non-dominant limb
OA	0.88* (p=0.004)	1* (p<.0001)
Control	0.717* (p=.045)	1* (p<.0001)

OA: Osteoarthritis; ∗Correlation is significant at the 0.05 level (2-tailed).

- **Discussion:**

This study aimed at establishing the concurrentvalidity of using Goniometer pro smartphone application in measuring passive JPS in patients with OA and asymptomatic control. Results showed significant positive correlation between the angle of repositioning error measured using the isokinetic dynamometer (gold standard) and the smartphone application in the two knees of patients and asymptomatic controls, implying that both methods can be used alternatively.

Smartphones have the advantage of being small in size, portable, easy to use, interactive and economic inprice compared to sophisticated laboratory instruments. Also,theyareequipped withaccelerometer, magnetometer and gyroscope sensors, which detect linear and angular motions of the phone. These built-in sensors with an appropriate

application turn the phone into a goniometric tool that can be used to assess jointROM and JPS.[17,18,19]

JPSreflects knee proprioception. In this study, we assessed passive JPS as it isindependentof muscle spindle input and motor command[20], so muscle and central nervous system status will not affect the results. JPS may be assessed by image capturing techniques, electrogoniometer and isokinetic dynamometers, the latter is considered the gold standard instrument for this measurement.The Isokinetic dynamometer was chosenin this study as a comparator due to its high validity, reliability and being the only method to assess passive JPS.

The results of the current study contradictwiththe findings of Ercan et al. (2017) who reported a significant difference between smartphone(iPhone 6 with Goniometer pro application) and the isokinetic dynamometer in measuring active knee JPS. However, Ercan and colleagues methodology differs from the current study as they measured only active JPS in healthy adult volunteers. Further, JPS was measured at a different range (30º , 45º and75º). Moreover, the measurement of smartphone and isokinetic were done at two separate occasions.[6]

On the other hand, Jones and colleagues (2014) tested the validity and reliability of "Simple Goniometer" application using iPhone and compared it to universal goniometer in assessing knee ROM in middle aged adults.The results showed positive correlation between the two devices (r = 0.96–0.98).[9] It should be emphasized that this study assessedROMand not JPS, and the comparator of this study which is universal goniometer which have an estimated measuring error of 5º to 10º .[21]

There are a few other studies that validated smartphone use to assess of proprioception acuity in other joints, For example, Lee and Han (2017) reported significantly high correlation (r = 0.6) between the“Sensor Kinetics Pro” application installed on Galaxy S4 smartphoneand the electrogoniometer in measuring ankle activeJPS in 20 healthy young adults.[10] Also, Edwards and colleagues(2016) validated the use of IPod in assessing shoulder flexion active JPS in nine healthy adults against amagnetic tracking device. The results showed no significant differences between the two devices($p>0.05$).[11]

To authors’ knowledge, this is the first study to investigate theconcurrentvalidity of smartphone in assessing passive JPS in patients with knee OA. The results of this study implies that smartphone can be used in clinical settings as a feasible, economic and portable tool toevaluate proprioception acuity and, hence, improve clinical decision making for patients' management and follow up.

However, this study is limited by testing only passive knee JPS in a single range.Also, this study tested only patients with primary OA, who never received surgical intervention.Future studies are recommended to measure passive and active JPS in different age groups, joint angles and OA severity.Also, to test inter-rater and intra-rater reliability.

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صلاحية الهاتف الذكي لقياس الاحساس بوضع المفصل في مرضى التهاب الركبة العظمي المفصلي: دراسة مسحية

الخلفية:يعتبر عجز المستقبلات الحسيه أحد عوامل تدهور التهاب الركبة العظمي المفصلي ، لذلك فإن التقييم والعلاج المناسب لهذا العجز مهم للتحكم في حالة مرضى التهاب الركبة العظمي المفصلي.حديثاً أصبحالهاتف الذكييستخدم لتقييم الجهاز العضلي الحركي. هناك القليل من التطبيقات الصالحة لقياس المستقبلات الحسية للمفاصل المختلفة والتي تلوح باستخدام واعد للهواتف الذكية كبديل اقتصادي لتقييم دقة المستقبلات الحسيه في العيادات ، ولكن صلاحية تقييم المستقبلات الحسيه مازالت بحاجة لمزيد من الدراسة ، لذلك فإن هذه الدراسة تهدف لاختبار صلاحية استخدام الهاتف الذكي في تقييم دقة المستقبلات الحسيه في مرضى التهاب الركبة العظمي المفصلي .

الطريقة:اثنان وثلاثون ركبة لستة عشر مشاركتم تقييمهم، ثمانية مشاركين لايعانون من أي شكوى مرضية في الركبه وثمانية مرضى مصابين في كلتا الركبتين بالتهاب الركبة العظمي المفصلي .تم قياس دقة المستقبلات الحسيه عن طريق الإحساس الداخلي السلبي بالوضع لمفصل الركبة بتطبيق الهاتف الذكي جونيومتر برو وجهاز البيودكسايزوكينيتكدينامومتر معاً.تم قياس مقدار الخطأ في إعادة تمثيل الزاوية ثلاث مرات لكل مشارك خلال الحركة السلبية وتم حساب متوسط هذه القياسات واستخدامها في التحليل الإحصائي .

النتائج:هنالك علاقة مترابطة إيجابية قوية بين قياساتالهاتف الذكي وجهاز الايزوكينتيك دينامومتر في قياس مقدار الخطأ في إعادة تمثيل الزاوية للمشاركين في كلتامجموعتا الدراسة . بالنسبة للركبة غير السائدة العلاقة الترابطية كانت مثالية في مجموعتا الدراسة، أما في الركبة السائدة فكانت العلاقة الترابطية مهمة إحصائياً ، إيجابية وعالية لكلتا مجموعتا الدراسة.

الخلاصة:تطبيق الهاتف الذكي المستخدم صالح كبديل لجهاز الايزوكينيتك دينامومتر لتقييم الاحساس الداخلي السلبي لوضع المفصل في مرضى التهاب الركبة العظمي المفصلي ومناظريهم .

الكلمات الدالة :الإحساس الداخلي بالوضع للمفصل،التهاب الركبة العظمي المفصلي ،الهاتف الذكي .