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Validity and Reliability of iPhone Application in Active Internal Rotation Measurement of Shoulder in Patients with Shoulder Pain

Omuz Ağrılı Hastalarda iPhone Uygulaması ile Omuz Aktif İç Rotasyon Hareketinin Ölçümünün Geçerlik ve Güvenilirliği

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ABSTRACT

Objectives: A low-cost alternative that can be used to measure shoulder range of motion (ROM) is the goniometer applications available on the iPhone®(Apple, Cupertino, CA, USA) and various smartphones. The validity and reliability of active internal rotation ROM measurement of shoulder with smartphone in patients with shoulder pain were investigated.

Methods: Eighteen patients with shoulder pain who applied to the physical medicine and rehabilitation, shoulder subspecialty outpatient clinic, and 18 volunteers who had not experienced shoulder pain before enrolled in the study. Shoulder internal rotation ROM measurements were conducted with both standard goniometer and iHandy application separately without seeing each other for each participant by one physiatrist and one physiotherapist.

Results: It is observed that the intraclass correlation coefficient values of Observer B, except from goniometric measurements, are >0.99 and consistency is very strong among practitioners. For both goniometer measurement and app measurement, the compatibility between the observers was found to be above 0.92.

Conclusion: This study shows that it is a reliable and valid method to measure shoulder internal rotation movement with the iPhone application.

Keywords: Goniometer; internal rotation; range of motion; shoulder; smartphone.

ÖZET

Amaç: Omuz eklem hareket açıklığını (EHA) ölçmek için kullanılabilecek düşük maliyetli bir alternatif, iPhone® (Apple, Cupertino, CA, ABD) ve çeşitli akıllı telefonlarda bulunan açıölçer uygulamalarıdır. Bu çalışmada omuz ağrısı olan hastalarda akıllı telefon ile omuzun aktif iç rotasyon EHA ölçümünün geçerliliği ve güvenilirliği araştırıldı.

Yöntem: Fiziksel Tıp ve Rehabilitasyon, omuz yan dal polikliniğine başvuran omuz ağrısı olan 18 hasta ve daha önce omuz ağrısı yaşamamış 18 gönüllü çalışmaya dahil edildi. Omuz iç rotasyon hareket açıklığı ölçümleri hem standart gonyometre hem de iHandy uygulaması ile her katılımcı için ayrı ayrı 1 fizik tedavi uzmanı ve 1 fizyoterapist tarafından yapıldı.

Bulgular: Uygulayıcılar arasında ICC değerlerinin büyük oranda 0,99'dan büyük olduğu ve tutarlılığın çok güçlü olduğu görülmektedir. Hem gonyometre ölçümü hem de uygulama ölçümü için, gözlemciler arasındaki uyumluluk 0,92'nin üzerinde bulundu.

Sonuç: Bu çalışma, iPhone uygulaması ile omuz iç rotasyon hareketini ölçmenin güvenilir ve geçerli bir yöntem olduğunu göstermektedir.

Anahtar sözcükler: Gonyometre; iç rotasyon; eklem hareket açıklığı; omuz; akıllı telefon.

Health technology is a rapidly progressing field. Since 2010, smart applications aimed at improving health have been used on smart phones with the support of health-care professionals or individual themselves. Google Android and Apple IOS, which have the application market, are expressed as two operating systems whose mobile quality and success are undeniable. These markets contribute to the development of new and potential research and development areas such as m-health applications.[1] In addition to the promoting the individual's own health, health-care professionals have also started to use these applications in diagnosis and treatment follow-up.

As a physiatrist, rheumatologist, or sports medicine physician, range of motion (ROM) measurement is one of the most essential and irreplaceable measurements in patient diagnosis and follow-up. Especially, for the glenohumeral joint, the most mobile joint in the human body, allowing flexion, extension, abduction, adduction, internal and external rotation movements, accurate, and reliable measurement of ROM is vital for monitoring physical and functional evaluation of the shoulder joint, as well as monitoring progress and recovery after surgery or non-operative management of shoulder pathology.[2]

Manual goniometer, which is one of the most widely used methods to evaluate ROM, was used for the first time during the First World War.[3] Until now, ROM has been measured by different methods such as digital goniometer,[4] digital inclinometer,[5] visual estimation method,[6] and other devices such as 3D gyroscope[7] or Kinect system.[8]

A low-cost alternative that can be used to measure shoulder ROM is the goniometer applications available on the iPhone (Apple, Cupertino, CA, USA) and various smartphones. These applications allow the user to accurately measure real-time angular changes and degrees of deviation.

There are validity and reliability studies about smartphone applications used for shoulder ROM measurement in the literature.[9-11] However, the most of these studies focus on external rotation and abduction. Glenohumeral internal rotation deficit is a common condition in athletes, especially in throwing athletes. In these patients, accurate measurement of shoulder internal rotation ROM is important during the rehabilitation process.

In our study, the validity and reliability of active internal rotation ROM measurement of shoulder with smartphone in patients with shoulder pain were investigated.

Figure 1. Measurement of shoulder internal rotation with iHandy application.

Methods

Eighteen patients with shoulder pain who applied to the physical medicine and rehabilitation, shoulder subspecialty outpatient clinic who agreed to participate in the study, and 18 volunteers who had not experienced shoulder pain before enrolled in the study. Participant age range was determined as 40–70 years. Research ethics approval was obtained from our university Ethics Committee (Approval Decision No: 2018/0200). All patients or their caregivers gave written informed consent.

In this study, the iPhone® 6S model (iPhone® is a trademark of Apple Inc, Cupertino, California) with the application of iHandy© (iHandySoft, Inc, New York, New York) was used. All iPhones used the same operating software version that was not updated during the data collection period. The IHandy® app is a free app with a visual display similar to that of the digital inclinometer in terms of digital size. In this study, due to its prevalence in the literature and its use in clinics, manual goniometer (gold standard) was chosen to be compared with this iPhone application.

The participants were asked to lie on the bed in supine position with shoulder to be measured at the edge of the bed. The measured shoulder was positioned at 90° abduction, 90° elbow flexion, and forearm at neutral position. A small towel was placed under the humerus to bring the elbow and glenohumeral joint to the same level. The participant was asked to bring the wrist closer to the bed in the direction of the little finger and was measured at the angle that the shoulder could not move without lifting the arm (Fig. 1). While measuring with goniometer, the pivot point of the goniometer was placed on the olecranon, the immobile rod of the goniometer was kept parallel to the bed, while the moving rod was kept parallel to the ulna; the angle was recorded at the end point of the movement. In the measurement

Table 1. Demographics characteristics of the participants

	Patient group (n=18) (%)	Control group (n=18) (%)	p
Gender (F/M)[a]	15/3 (83.3)/(16.7)	14/4 (77.8)/(22.2)	0.67
Marital status (married/single)[a]	14/4 (77.8)/(22.2)	15/3 (83.3)/(16.7)	0.67
Age (year)[b,c]	58.17±7.32/61 (45–66)	54.61±5.32/54.5 (46–64)	0.09
Height (cm)[b,c]	161.56±6.18/160 (150–175)	160.94±8.38/160.5 (150–180)	0.68
Weight (kg)[b,c]	78.61±12.09/79 (56–100)	69.11±15.79/63 (49–105)	0.06

F: Female; M: Male; a: Number of cases (percent); b: Mean±tandard deviation; c: Median (minimum–maximum).

Table 2. Average and standard deviation values of the measurements (n=36)

	Observer A		Observer B	
	Goniometer	App	Goniometer	App
1 week	61.48±10.09	61.87±9.98	62.09±11.41	61.73±10.00
2 week	62.30±9.93	62.20±9.92	61.95±9.73	62.27±9.74

Table 3. Intra-observer and inter-observer reliability results (ICC and 95% CI)

	Goniometer	App
Intra-observer (A)	0.991 (0.983–0.996)	0.996 (0.992–0.998)
Intra-observer (B)	0.872 (0.764–0.933)	0.995 (0.989–0.997)
Inter-observer (A/B)	0.927 (0.882–0.958)	0.995 (0.991–0.997)

ICC: Intraclass correlation coefficient; IC: Confidence interval.

made with the application, the phone was held parallel to the ulna and the value displayed on the screen was recorded. The participant was asked to repeat the movement if his/her shoulder lift up of bed, straightened his/her elbow, or did anything that would disrupt her movement pattern.

Each measurement was repeated 3 times; and after 2 weeks, the control measurements were made by repeating 3 times. Measurements were conducted separately in different cabinets without seeing each other for each participant by one physical medicine and rehabilitation specialist and one physiotherapist. The measurements were recorded in separate locations until all participants were completed.

Statistical Analysis

Statistical analysis of the data was done using SPSS 25.0 package program (IBM, Chicago, IL). All descriptive statistics of the measurements are presented as mean±standard deviation and median (minimum-maximum). Frequency values (number of cases) for categorical variables are shown together with their percentages. Study, intra-observer and inter-observer reliability of measurements made at two different times by two different practitioners, was tested using a two-way mixed model with an in-class correlation coefficient (intraclass correlation coefficient [ICC]). The confidence interval for the in-class correlation coefficient was determined as 95%, and the results were presented as the correlation coefficient (GA: Sublimit-upper limit). Statistical significance level was determined as $p<0.05$ for all analyzes.

Results

A total of 36 people, 29 female (80.6%) and 7 male (19.4%), participated in the study. The demographics of the participants are shown in Table 1.

There was no statistical difference in gender, marital status, age, weight, and height parameters between the patient and control groups. The mean and standard deviation values of the measurements made by the two observers in the 1st and 2nd weeks are shown in Table 2. Test – retest reliability was calculated for the Observer A and the Observer B for the inter-observer reliability. It is observed that the ICC (in-class correlation coefficient) values of Observer B, except from goniometric measurements, are greater than 0.99 and consistency is very strong among practitioners. Inter-observers' reliability was determined by in-class correlation coefficient values. For both goniometer measurement and app measurement, the compatibility between the observers was found to be above 0.92. In Table 3, intraclass and interclass correlation coefficient values are presented with 95% confidence interval.

The validity of the application was examined through the relationship of goniometer and application. According to the correlation coefficient values, goniometer and iHandy application are observed to have a strong relationship (ICC=0.928 and GA=0.884–0.995).

In the first measurements between Observer A and Observer B, both $t(35)=-0.66$, $p=0.51$ in the goniometer and

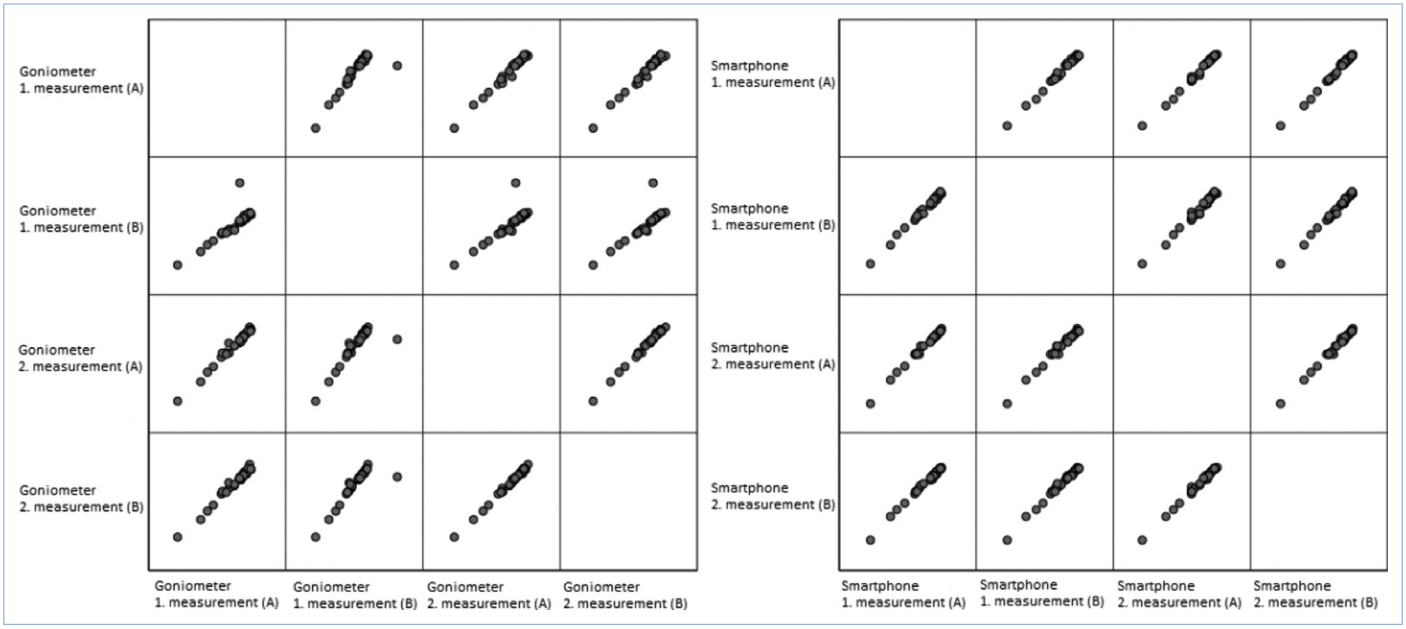

Figure 2. (1 and 2) measurements of observer A and B of **(a)** goniometer **(b)** smartphone.

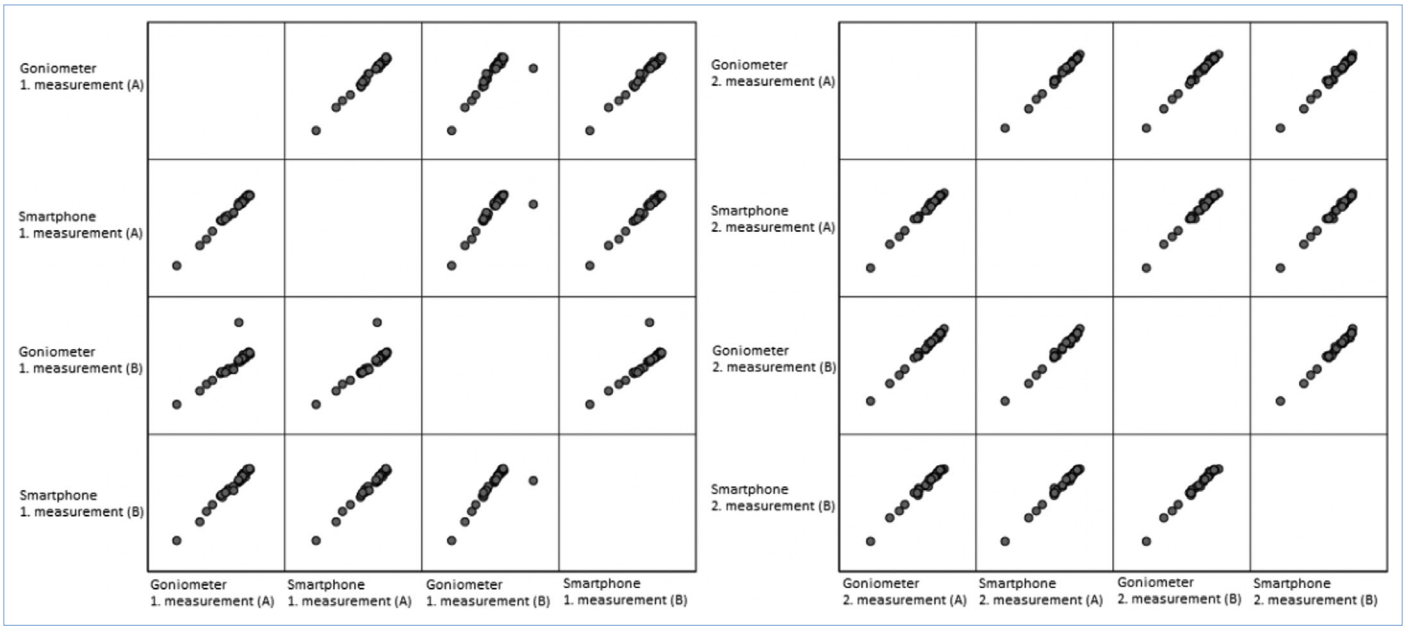

Figure 3. Smartphone and goniometer measurements of observer A and B of **(a)** one measurement **(b)** two measurement.

t (35)=0.86, p=0.40 in the app. No statistically significant difference was found. The scatterdot charts below demonstrate the relationships between measurements visually based on correlation values (Fig. 2, 3).

Discussion

Integrating smartphones into clinical applications can be quite practical and economical, but it is important to test their validity and reliability before using them. Studies in the literature for these applications are quite limited and inadequate.

In this study, it was seen that active shoulder internal rotation measurement made with the iPhone application can be a reliable and valid alternative to the standard goniometer. In the study of Cuesta-Vargas et al.[11] comparing the measurement of shoulder abduction with a smartphone application and universal goniometer, reliability values between the investigators were found to be better for par-

ticipants with shoulder pain, but no reliability among the investigators was found for healthy individuals. Pourahmadi et al.[12] measured lumbar flexion and extension angles with an iPhone application and an inclonometer and stated that the iPhone application has reliability within and between the investigators (ICC>0.85). Werner et al.[13] in their study first visually predicted the normal joint movements of 24 healthy individuals' bilateral shoulder joints and 15 post-operative patients with shoulder disease, then compared results with a smartphone application and goniometer. In their study, the ICC value of the shoulder internal rotation measurements with goniometer was 0.64, and with the smartphone application was 0.81. Furthermore, Shin et al.[14] investigated ROM of shoulder using an inclinometer-based application as compared to goniometer. Both the goniometric and inclinometric measurements showed satisfactory inter-observer reliability except for internal rotation at 90° of abduction, which was <0.7 (range, 0.63–0.68). Despite these last two studies, in our study, both the goniometer and the app measurements among the practitioners were found to be ICC values of 0.92 and reliable. It is seen that the ICC value of the most measurements is >0.99 and the consistency of the practitioners is very strong.

Smartphone goniometer apps are widely available to most smartphone users, giving it an advantage over the standard goniometer or other more sophisticated measuring tools. Furthermore, accessibility of the goniometer is limited to the areas of expertise related to the musculoskeletal system, and in this respect, goniometer applications have the advantage of widespread usability.

Furthermore, a good correlation was observed between a physical medicine and rehabilitation specialist and a physiotherapist, who are the most frequent goniometer users. With the advancement of technology, considering that most people use smartphones, this phone application, which can be used for free, can be considered more attainable compared to the standard goniometer.

Limitations

The results of the study are single-center results and cannot be generalized. In the future studies, it is recommended to conduct studies with larger sample size and equal distribution of age, gender, and body mass index and it is also recommended to evaluate other shoulder movements.

Conclusion

This study shows that iPhone iHandy application showed an excellent reliability and validity in shoulder internal rotation movement measurement compared with standard goniometer. These applications may assist physicians accurate follow-up of patients, obtain a reliable measurement, and also give an opportunity to record measurements and send it to patients. Studies to be carried out with larger samples are important to support the reliability of such applications.

Disclosures

Ethics Committee Approval: The study protocol was approved by the Ethics Committee of Istanbul Medeniyet University Goztepe Training and Research Hospital (date: 30.05.2078, number: 2018/0200).

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