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Comparison of Two Different Proprioception Measurement Methods in the Shoulder Joint

Omuz Ekleminde İki Farklı Propriyosepsiyon Ölçüm Yönteminin Karşılaştırılması

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ABSTRACT

Aim: Proprioception assessment is important in shoulder rehabilitation. Proprioception sense can be evaluated with different methods in the clinical setting. The aim of this study was to compare shoulder proprioception measurements made with universal goniometer and isokinetic system.
Methods: A total of 52 healthy individuals with a mean age of 24.6 ±4.29 years were included in the study. Shoulder proprioception was evaluated three times with a universal goniometer and isokinetic device at 30, 45 and 60 degrees shoulder flexion angles with eyes closed in a sitting position and mean values were recorded.

Results: When the results obtained with the two measurement methods were compared, it was determined that there was a significant difference between the mean values (for 30, 45 and 60 degrees shoulder flexion angles, p=0.003, 0.005, 0.000, respectively) and there was no correlation relationship between the results of the two measurement methods (p<0.05). However, when the mean deviation from the target angle was compared with both measurement methods, it was determined that there was no significant difference between the measurement methods (p<0.05).

Conclusion: The findings of this study demonstrated that when shoulder proprioception was measured using a goniometer or an isokinetic dynamometer at various angles, different values could be obtained. However, since the differences compared to the target angle are similar for the two measurement methods, both assessment methods can be used for proprioception evaluation.

Keywords: Assessment, shoulder, proprioception, rehabilitation

ÖZ

Amaç: Omuz rehabilitasyonunda propriyosepsiyon değerlendirmesi önem taşımaktadır. Propriyosepsiyon duyusu klinik ortamda farklı yöntemlerle değerlendirilebilir. Bu çalışmanın amacı universal gonyometre ve izokinetik sistem ile yapılan omuz propriosepsiyon ölçümlerini karşılaştırmaktı.
Gereç ve Yöntem: Çalışmaya yaş ortalaması 24,6 ± 4,29 yıl olan toplam 52 sağlıklı birey dahil edildi. Omuz propriosepsiyonu, oturur pozisyonda gözler kapalı iken 30, 45 ve 60 derece omuz fleksiyon açılarında universal gonyometre ve izokinetik cihaz ile üç kez değerlendirildi ve ortalama değerler kaydedildi.

Bulgular: İki ölçüm yöntemi ile elde edilen sonuçlar karşılaştırıldığında, ortalama değerler arasında anlamlı fark olduğu (30, 45 ve 60 derece omuz fleksiyon açıları için sırasıyla p=0,003, 0,005, 0,000) ve iki ölçüm yönteminin sonuçları arasında korelasyon ilişkisi olmadığı tespit edildi (p<0,05). Ancak hedef açıdan ortalama sapma her iki ölçüm yöntemi ile karşılaştırıldığında ölçüm yöntemleri arasında anlamlı bir fark olmadığı tespit edilmiştir (p<0,005).

Sonuç: Bu çalışmanın bulguları, omuz propriyosepsiyonu gonyometre veya izokinetik dinamometre kullanılarak çeşitli açılarda ölçüldüğünde farklı değerler elde edilebileceğini göstermiştir. Bununla birlikte, hedef açıya kıyasla farklılıklar iki ölçüm yöntemi için benzer olduğundan, her iki değerlendirme yöntemi de propriyosepsiyon değerlendirmesi için kullanılabilir.

Anahtar Kelimeler: Değerlendirme, omuz, propriosepsiyon, rehabilitasyon

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1. INTRODUCTION

The sense of position and motion of the limbs was first referred to as proprioception by Sir Charles Bell in the early 1830s as the "sixth sense" (1). Sherrington (2) went into greater detail about it at the start of the 20th century.

Proprioception, which means "belonging to oneself," is derived from the Latin word proprius. The full Turkish translation is "perception of one's own self" (3). Thermoreception, nociception, equilibrioception, mechanoreception, and proprioception are among the somatosensory senses, also referred to as the sixth sense. Proprioception includes the senses of passive and active joint position, kinesthesia, force or tension, and feeling of speed change (3-5).

Our capacity to sense where our limbs and joints are in relation to our bodies and environments (both in position and while moving) without visual feedback is known as proprioception. Sensorimotor control depends on proprioception. Proprioception is crucial for movement acuity, joint stability, coordination, and balance, as well as for sensorimotor control and regulation of muscle tension based on feedback and feedforward feedback (2,4).

Proprioception or proprioceptive acuity is a complex system that requires both peripheral and central systems to work in harmony with each other. Since sensory information is derived from changes in internal structures, it is also recognised as interoceptive information. Evidence for the major proprioceptive receptor supports muscle afferent input, particularly from muscle spindles. These receptors are specialised fibres within the muscle that detect the change in muscle length as well as the rate of contraction. They also detect body part movement as a first derivative of length, i.e. the rate of change in length. During contractions, the muscle spindle is under fusimotor (gamma system) control, which has the capacity to change the calibration or sensitivity of the receptor by changing its internal length (3-7).

According to Proske and Gandevia, the perception of joint position and movement is also influenced by cutaneous receptors found in the skin, particularly those found in the fingers, elbow, and knee (6). Joint structures also contain receptors that resemble cutaneous receptors. It is possible to detect static joint position, intra-articular pressure, and possibly joint motion in terms of amplitude and velocity thanks to ruffini bodies found in the joint capsule, ligaments, and menisci. Deeper tissues' Pacinian corpuscles are responsive to changes in velocity. Movement restrictions affect the Golgi tendon organ, which is a part of the ligaments and menisci (5). These sensory inputs from within the body contribute to proprioception (5).

Tests to assess joint position sense, kinesthesia, or force sense should be used in clinical proprioception assessments. Custom-built instruments or expensive computer interfaces are frequently used in laboratories. It can be difficult to use specialised and computerised systems during clinical practice and to access these devices at all times. In a clinical setting, goniometers, inclinometers, pressure sensors, and laser pointers are accessible and simple to use. There is also potential for new, reasonably priced, and precise technology, such as cellphones with integrated gyros and accelerometers, Wii Balance Board, Kinect and other tecnologic systems (4).

A goniometer is a tool used to measure the angle of a joint in the body. It is a simple and inexpensive device that is widely used in physical therapy and sports medicine to assess an individual's range of motion and joint stability. In addition to measuring joint angles, a goniometer can also be used to assess proprioception. The goniometer is a useful tool for assessing proprioception as it provides objective data that can be used to guide the development of effective rehabilitation plans. Its low cost and ease of use make it a valuable tool in both clinical and research settings (8,9). Isokinetic testing is a type of physical performance test that measures an individual's strength and muscular endurance through controlled joint movements. The Isokinetic Dynamometer System is also used to assess proprioception, which is the ability of an individual to perceive the position and movement of their body in space. The system measures the individual's ability to control their movements and maintain balance during exercises that simulate real-life movements (10,11). With the hypothesis that proprioception measurements with goniometer and isokinetic system will be similar, the aim of this study was to compare shoulder proprioception measurements made with universal goniometer and isokinetic system.

2. METHODS

The study was carried out between April 2023 and May 2023 at Marmara University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation Laboratory. *The ethics approval for the study was obtained from the Ethics Committee of Marmara University, Faculty of Health Sciences (30.03.2023/49)* and it was conducted in accordance with the Declaration of Helsinki. Each participant signed informed consent forms after informing about the study. A descriptive and cross-sectional study was conducted.

2.1. Participants

The study sample was selected from healthy young individuals who are university students attending face-to-face education. Participants were invited to the study via email and whatsapp groups. Being over 18 years of age and healthy were the inclusion criteria. Injury or surgical operation related to the shoulder joint, any congenital or orthopedic problem, presence of neurological and rheumatic diseases, and pregnancy were determined as exclusion criteria.

2.2. Assessment

To assess proprioception using a goniometer and the isokinetic system the individual was asked to perform movements such as flexion and extension of a joint while blindfolded. The same physical therapist then measured the joint angle using the goniometer or isokinetic device and compared it to the target angle. The difference between the actual angle and the target angle provides information about the individual's ability to perceive the position of their joint in space (4,9,10). Resting the participant for 2 – 3 minutes between two different measurements requested.

Goniometric Measurement

To perform goniometric measurements, the participant was asked to sit on a chair with back support. They were instructed to sit with their feet flat on the ground and their knees flexed at 90 degrees. The measurements were initiated by placing the pivot point of the goniometer (Baseline®, 12-inch plastic goniometer, Fabrication Enterprises, Inc: White Plains, NY / USA) on the acromion of the participant's shoulder joint. The fixed arm of the goniometer was positioned parallel to the participant's midaxillary line. The movable arm was fixed parallel to the humerus and followed the humerus during shoulder flexion to measure the angles. Prior to measurements, the participant was asked to perform angular movements with their eyes open and the positions of the angles were taught in three repeated cycles. After the learning period, the participant was asked to close their eyes and three repetitions of 30, 45, and 60-degree shoulder flexion angles were performed and the mean values were recorded.

Isokinetic Dynamometer Measurement

Isokinetic Dynamometer assessment was performed with Biodex® device (Biodex System 3 Pro Multi Joint System®, Biodex Medical Inc, Shirley, NY / USA) which can be used for many different tests and are designed to measure parameters such as weight lifting capacity, force generating capacity, range of motion, muscle strength, endurance and proprioception.

For measurements, the participant was seated on the Isokinetic Dynamometer device with their feet in full contact with the ground. Then they were asked to position their knees at 90 degrees of flexion. After the positioning process was completed, the relevant arm apparatus of the device was adjusted to fit the individual. During measurement, the test procedure was carried out with the participant's arm moving in full extension. First, the participant was taught the activity they were going to perform. The activity consisted of the participant performing 30, 45, and 60 degrees of shoulder flexion angles while the movement was monitored on the device screen and the participant's eyes were kept open to observe the movement. The learning process of each angle consisted of three repetitions. After the teaching process was completed, the participant was asked to close their eyes and sequentially find these angles by flexing their shoulders with the relevant apparatus of the device (Figure 1). These measurements were repeated three times, and the measurement averages were recorded.

Figure 1. *Proprioception assessment with Biodex® Isokinetic Device.*

2.3. Statistical Analysis

SPSS (Statistical Package for Social Sciences) Windows v22.0 (SPSS Inc, IBM Corp, Armonk, New York) was used for all statistical analyses in the study. Mean and standard deviation (SD) were used for quantitative results, and percentage (%) values were used for qualitative results. Normal distribution of data was assessed by the "One-Sample Kolmogorov-Smirnov Test" and by examining histograms. Pearson correlation analysis was used to evaluate the relationship between parameters. We evaluated the difference between measurement methods with the Mann-Whitney U test. The level of statistical significance was set at $p<0.05$.

3. RESULTS

This study included 19 male and 33 female participants with a mean age of 24.6 ± 4.29 years. The mean height was 165.7cm, mean weight was 64.7 kg and mean BMI was 25.3.

The evaluations conducted with Goniometer and Isokinetic Dynamometer assessment system at 30, 45, and 60 degrees of shoulder flexion angles are presented in Table 1.

Table 1. *Differences between angular measurements.*

Target Shoulder Flexion Angles (n=52)	Goniometer Measurements Mean (SD) Median (min – max)	Isokinetic Dynamometer Measurements Mean (SD) Median (min – max)	p value
30 degrees	32.1 (3.4) 31.1 (25.6 – 50)	30.4 (2.2) 30.6 (25 – 35.6)	**0.003**
45 degrees	45.6 (2.1) 45.8 (41 – 51.6)	44.1 (2.6) 44.1 (37.9 – 54.8)	**0.001**
60 degrees	60.1 (4.6) 60.6 (33.6 – 66.6)	58.5 (2.4) 58.7 (52.7 – 63.3)	**0.000**

SD: Standart Deviation, min:minimum, max:maximum, Statistical Method: Mann-Whitney U Test

The box plot and violin plot images of the angular measurements are shown in Figure 2. The box plot and violin plot images present the graphical representations of the means of the measurements and the numerical values of the outliers. Additionally, the plots provide insights into the normal distribution of the measurements. Upon examining the graphs, it is anticipated that the angular measurements do not adhere to a normal distribution.

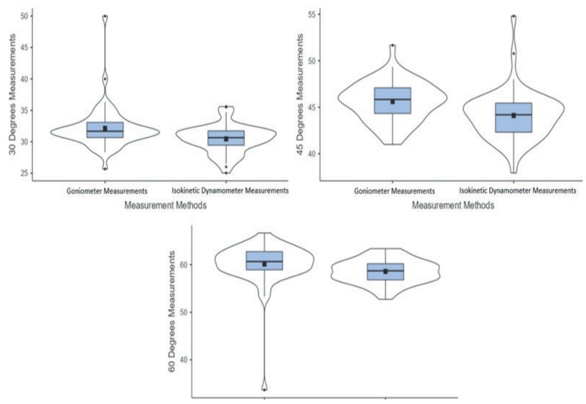

Figure 2. *Violin and box plots of angular values measured in the study.*

The deviations of the angular measurements from the target angle form the basis of the study. Therefore, the distances between the obtained values from the target angular value were calculated. After determining the distances to the angular target, the absolute values were taken for the negative values. Through the descriptive analysis conducted based on the absolute values, it was observed that the distance values from the target angles did not conform to a normal distribution, as indicated by the Shapiro-Wilk test results ($p<0.05$).

Due to the non-normal distribution of the measurements, the Mann-Whitney U test was employed to evaluate the significance level of the differences between the measurements. According to the test results, no significant difference was found between the goniometer measurements and the measurements conducted with the Isokinetic Dynamometer device (U = 1114, $p>0.05$ for 30-degree measurements; U = 1317, $p>0.05$ for 45-degree measurements; U = 1311, $p>0.05$ for 60-degree measurements; Table 2; Figure 3).

Table 2. *Evaluation of the difference between the distance values to the target angles.*

	Statistic	p	Mean Difference	Effect Size
MD in 30 Degrees	1114	0.122	0.37	0.1764
MD in 45 Degrees	1317	0.822	0.06	0.0259
MD in 60 Degrees	1311	0.79	0.1	0.0307
Note H0 μ0 ≠ μ1				

MD: Measurements Distance, Statistical Method: Mann-Whitney U Test

There was no significant difference found between the medians of the distance values from the target angle in the goniometric measurements (30 degrees = 1.67; 45 degrees = 1.67; 60 degrees = 1.67) and the medians of the measurements conducted with the Isokinetic Dynamometer device (30 degrees = 1.61; 45 degrees = 1.55; 60 degrees = 2.29) (Table 2, Figure 3).

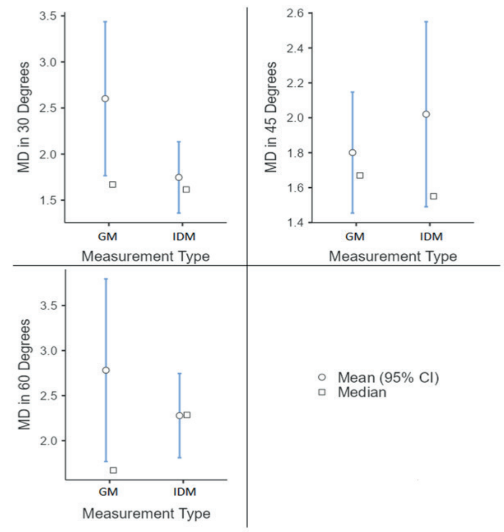

Figure 3. *Descriptive plots of distances to target angles according to measurement methods.*

*(*MD: Measurements Distance; GM: Goniometric Measurements; IDM: Isokinetic Dynamometer Measurements; CI: Confidence Interval)*

Non-parametric Spearman's rho correlation analysis was conducted to assess the relationship between the distances from the target angle in the goniometric measurements and the measurements performed with the Isokinetic Dynamometer device for the target shoulder flexion angles in the correlation analysis considering the differences in measurement methods for the measured angular values, no significant relationship was found (r = – 0.003, $p>0.05$ for 30-degree measurements; r = – 0.216, $p>0.05$ for 45-degree measurements; r = – 0.181, $p>0.05$ for 60-degree measurements). The correlation plot for the respective measurements is provided in Figure 4.

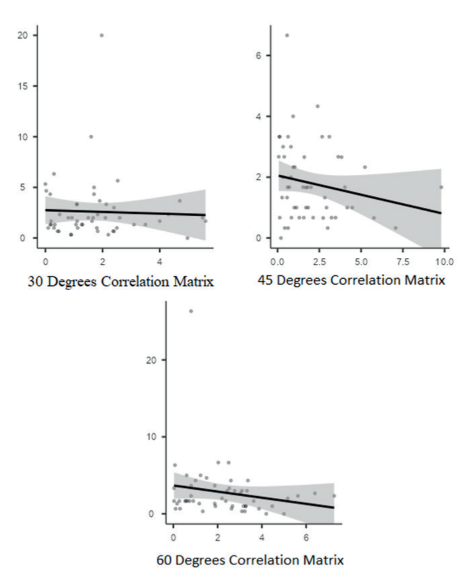

Figure 4. *Correlation matrix of distance to target angle according to measurement methods.*

4. DISCUSSION

The results of this study showed that different values can be obtained when shoulder proprioception was evaluated at different angles using a goniometer or an isokinetic dynamometer. It was also found that the results obtained with two different proprioception assessment methods were not correlated. When the mean deviation from the target angle was compared with both measurement methods, it was determined that there was no significant difference between the measurement methods.

According to the median values, the results of proprioception assessment with isokinetic dynamometer were closer to the target angle at 30 and 45 degrees shoulder flexion, while the results of proprioception assessment with goniometer were closer to the target angle at 60 degrees shoulder flexion.

The proprioceptive mechanism integrates the static and dynamic functions of joint stabilizers.

Both passive (bony structures, capsule, and ligaments) and active (muscles) stabilizers contribute to the stability of the shoulder. A watertight capsule, corresponding surfaces, and joint fluid all work together to create negative pressure, which is what gives an object its stability at rest. The joint maintains its stability while in motion by balancing muscle activity and by capsular and ligamentous restraints in extreme motion. The central nervous system is in charge of stabilizing the system [12-16]. Shoulder proprioception has been shown to be affected after surgical treatments and shoulder problems (15,16). Therefore assessment of shoulder proprioception is of clinical importance for physiotherapists.

In a systematic analysis of shoulder proprioception assessment methods in the literature, 21 studies were included (17). The researchers reported that the most reliable movement in the evaluation of shoulder proprioception was internal rotation in 90° abduction and the device was isokinetic dynamometer (17). Shoulder proprioception with shoulder flexion movement was evaluated in 6 studies (17). However, isokinetic evaluation was preferred for evaluation in most of the studies. Only one study examined the validity and reliability of using a goniometer for shoulder proprioception assessment (17,18).

Vafadar et al. (2016) reported that in shoulder proprioception evaluations performed with a goniometer, there was more error at small range of motion values of shoulder flexion, while this margin of error decreased at medium and high angle values (18). In our study, the maximum difference between the target angle and the shoulder flexion angle reached by the subject was 30 degrees, but the difference between the target angle and the achieved angle was smaller for 60 and 90 degrees of shoulder flexion. Vafar et al. (2016) reported interrater and intrarater intraclass correlation coefficients for the goniometer as .60 and .50, respectively; and the authors did not recommend goniometry for shoulder proprioception assessment in the clinic (18).

In a recent study, shoulder internal rotation and external rotation position sense were evaluated with an isokinetic dynamometer and the researchers reported that the intra-rater and inter-rater reliability of the internal rotation position sense tests were moderate to good, and the intra-rater test reliability of external rotation was poor and inter-rater reliability was moderate to good (19). Inter-rater and inter-rater agreement for shoulder flexion position sense assessment was not examined in the present study.

Batista et al. (2006) evaluated the range of motion of the knee joint in 38 healthy subjects with a universal goniometer and isokinetic dynamometer and reported that the results were correlated (0.90) and reliable. The difference between the results of this study and other studies may be due to the evaluation of the knee joint or the range of motion of the joint.

To the best of our knowledge, there is no study in the English and Turkish literature that measured shoulder proprioception with isokinetic dynamometer and goniometer and compared the results obtained.

Another important finding of this study is that there was no correlation between the measurements made by goniometer and isokinetic dynamometer. There was a difference of 0.37, 0.06 and 0.1 between the mean values obtained with both measurement methods at 30, 60 and 90 degrees of shoulder flexion, respectively, so we think that if the number of individuals included in the evaluation increases, there will be agreement between the two measurement methods.

Goniometer assessment results may vary depending on the skill and experience of the assessor. On the other hand, isokinetic dynamometer devices offer a more technological and standardized approach. These fundamental differences between these two techniques may lead to a certain lack of correlation between the measurement processes, even though the overall measurement values are similar. This result of the present study shows that more care should be taken when using different measurement techniques. An important issue to consider is that it is not possible for clinicians to perform isokinetic device assessments for every individual undergoing shoulder rehabilitation.

Vafadar et al. (2016) recommended clinicians to use an inclinometer and laser pointer for proprioception measurement during shoulder rehabilitation.

Limitations

In this study, only proprioception assessment of shoulder flexion movement was performed, and proprioception assessment of other range of motion positions of the joint was not performed. Another limitation of our study is that intrarater and interrater reliability assessments were not performed for the two measurement methods. We suggest that in future studies, intra – and interrater reliability analyses of different methods should be performed with a larger sample size including different age groups so that physiotherapists working in the field of shoulder rehabilitation can be provided with methods that they can apply in the clinic.

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