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THE INTER-RATER AND INTRA-RATER RELIABILITY OF GLENOHUMERAL JOINT POSITION AND MOVEMENT SENSE TESTS APPLIED USING AN ISOKINETIC DYNAMOMETER

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ORIGINAL ARTICLE

ABSTRACT

Purpose: This study aimed to test the inter-rater and intra-rater reliability of glenohumeral joint (GHJ) position and movement sense tests of an isokinetic dynamometer in healthy individuals.

Methods: The study included 17 healthy subjects (8 female). GHJ position and movement sense tests were applied by two raters with an isokinetic dynamometer to the dominant extremity. Both tests were performed while GHJ positioned 90^0 abduction and elbow flexion, reference angles for position sense were 30^0-60^0 internal and external rotation and movement sense tests were conducted at 0.1°/s to the both internal and external rotation directions. The error score, by averaging the three trials, was measured as the absolute difference between the target angle and the observed angle.

Results: The different error types calculated for position sense were in the range of mean 0.02±1.62-5.42±1.74. The ICC value for the different error types was determined in the range of 0.038 - 0.657 for the intra-rater tests, and 0.095-0.779 for the inter-rater tests. The movement sense test results for different directions and angles ranged from 9.61±2.61 to 11.18±2.89. The ICC values for movemeent sense were in the range of 0.687-0.912 for the intra-rater tests, and 0.844-0.925 for the inter-rater tests.

Conclusion: The isokinetic dynamometer showed moderate-good intra-rater and inter-rater test reliability in the measurement of the GHJ internal rotation movement sense. The intra-rater test reliability was poor in external rotation but the inter-rater test reliability was moderate-good. However in the measurement of movement sense, the isokinetic dynamometer showed intra-rater and inter-rater test reliability at an excellent level. The conformity of both the position and the movement sense tests, and therefore, the repeatability, was extremely good.

Keywords: Kinesthesia, Proprioception, Reliability, Shoulder.

İZOKİNETİK DİNAMOMETRE İLE YAPILAN GLENOHUMERAL EKLEM POZİSYON VE HAREKET HİSSİ TESTLERİNİN DEĞERLENDİRİCİLER ARASI VE DEĞERLENDİRİCİLER İÇİ GÜVENİRLİKLERİ

ARAŞTIRMA MAKALESİ

ÖZ

Amaç: Bu çalışmanın amacı; sağlıklı bireylerde izokinetik dinamometrenin glenohumeral eklem (GHE) pozisyon ve hareket hissi testlerindeki değerlendiriciler içi ve değerlendiriciler arası test güvenilirliğini araştırmaktır.

Yöntem: Çalışmaya toplamda 17 sağlıklı katılımcı (8 Kadın) dahil edildi. Katılımcıların dominant ekstremitesine izokinetik dinamometre ile glenohumeral eklem pozisyon ve hareket hissi testi iki farklı değerlendirici tarafından yapıldı. Her iki test de glenohumeral eklem 90^0 abdüksiyonda ve dirsek eklemi 90^0 fleksiyonda yapıldı. Pozisyon hissi için referans açıları 30^0–60^0 internal ve eksternal rotasyondu, hareket hissi testi ise 0.1°/s hızda internal and eksternal yönlerinde yapıldı. Hata skoru, hedef açı ile gözlemlenen açı arasındaki mutlak fark üç denemenin ortalaması alınarak kaydedildi.

Sonuçlar: Pozisyon hissi için hesaplanan farklı hata türü ortalamaları; 0.02±1.62 ile 5.42±1.74 arasındaydı. Farklı hata türleri için; değerlendiriciler içi testlerin ICC değeri 0.038 ile 0.657 arasında, değerlendiriciler arası testlerin ICC değerleri 0.095 ile 0.779 arasında değişmekteydi. Farklı yön ve açılara ait hareket hissi test sonuçları 9.61±2.61 ile 11.18±2.89 arasındaydı. Hareket hissi için değerlendiriciler içi testlerin ICC değerleri 0.687 ile 0.912 arasında, değerlendiriciler arası testlerin ICC değerleri 0.844ile 0.925 arasında bulundu.

Tartışma: İzokinetik dinamometre GHE internal rotasyon hareket hissini ölçmede orta-iyi düzey değerlendiriciler içi ve değerlendiriciler arası test güvenilirliği göstermiştir. Eksternal rotasyon değerlendiriciler içi test güvenilirliği zayıftır fakat değerlendiriciler arası test güvenilirliği orta-iyi düzeydedir. Diğer taraftan izokinetik dinamometre hareket hissi ölçümünde mükemmel seviyede değerlendiriciler içi ve değerlendiriciler arası test güvenilirliği göstermiştir. Hem pozisyon hem de hareket hissi testlerinin uyumu ve dolayısıyla tekrarlanabilirliği oldukça iyidir. Ayrıca her iki test için de izokinetik dinamometre küçük farkları ortaya çıkarmada başarılıdır.

Anahtar kelimeler: Kinestezi, Propriyosepsiyon, Güvenirlik, Omuz.

INTRODUCTION

The proprioceptive system is a subunit of the somatosensorial system, which works introceptively (1). Proprioception functions in the regulation of motor control, collecting multisensorial neurological feedback (2). In other words, the total sensory information including the production, perception, estimation and simulation of information related to the direction and speed of the joint movement, the joint position and the amount of force producing the movement, can be defined as proprioception (3).

The majority of studies related to proprioception have been on the subject of the knee or ankle joint (4,5), and few studies have investigated shoulder proprioception (6-8). There is a reciprocal relationship between proprioception and shoulder girdle injuries. While proprioception deficits are one of the factors laying the ground for shoulder injuries, shoulder injuries may cause proprioception deficits (6-8). Therefore, shoulder girdle proprioception is often used in the diagnosis and treatment of injuries involving the shoulder region (9,10). However, the limited literature on this subject causes some difficulties to be experienced in clinical practice. There is therefore a need for new valid and reliable methods which can be used in the clinic for the measurement of shoulder girdle proprioception, and the relationship between proprioception and shoulder injuries, and for studies to examine the validity and reliability of existing proprioception measurement methods in different populations, and the effect on shoulder proprioception of different exercise models used in shoulder rehabilitation (1,2,4,11,12). Recent evidence has shown that the glenohumeral joint (GHJ) makes a greater contribution to shoulder joint proprioception (13). The methods providing the most reliable information about GHJ proprioception are methods which passively measure joint position and movement sense. One of the most reliable measurement methods according to current information is the isokinetic dynamometer (2). However, the reliability of GHJ position and movement sense tests performed with a dynamomter has not been investigated in healthy individuals and /or different pathology groups (1).

The aim of this study was to examine the reliability of GHJ position and movement sense tests performed with an isokinetic dynamometer on healthy individuals at different times by the same rater and by different raters.

MATERIAL AND METHODS

Participants

The minimum sample size of the study was determined as 17 participants when assuming 80% power, alpha set at 0.05, acceptable reliability value as 0.65 for two raters and %10 dropout rate.

The study sample was formed of volunteers from the administrative and academic personnel of the Health Sciences Faculty and Nursing Faculty of Necmettin Erbakan University. Evaluation was made of a total of 17 subjects, comprising 9 males and 8 females with a mean age of 27.41±4.96 years, mean height 174±10.20 cm, and mean body weight of 70.55±13.49 kg.

The study exclusion criteria were defined as the presence or history of shoulder injury, a history of shoulder surgery, the presence of benign general joint laxity, shoulder disease related to cervical or thoracic verebrae, disease related to the peripheral and/or central nervous system, the use of psychoactive or vasoactive drugs, or regular participation in sports involving overhead activity (basketball, volleyball) (14-16). An anonymous demographic information form was used to question the exclusion criteria, and the Beighton joint laxity scoring, and the Quick-DASH upper extremity functional forms were used. Volunteers who did not meet any of the exclusion criteria were informed both verbally and in writing about the study. Signed informed consent was obtained from all the study participants.

Measurements

After identification of the study participants, GHJ proprioception measurements were taken 3 times at 1-week intervals. The measurements were taken from the dominant extremity, which was determined using the Edinburgh Handedness Questionnaire (17). Position and movement sense tests were used in the measurement of proprioception. After identification of the study participants, the two raters together took pilot measurements from 10

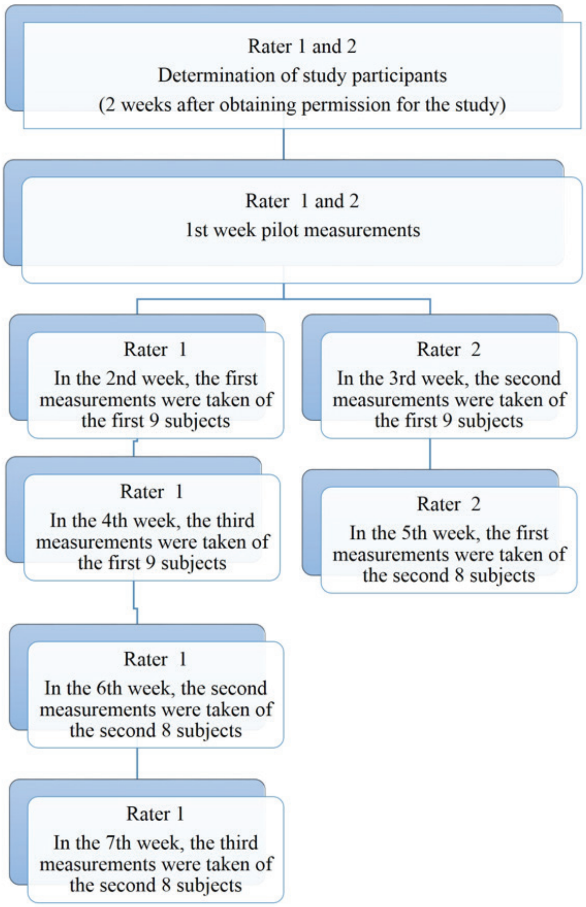

Figure 1. Flowchart of the Study

subjects. The data were collected within 6 weeks of the study announcement and identification of the participants. All the measurements were taken on an isometric dynamometer (Cybex Humac 2009®/ Norm™ CSMi) in the Sports Medicine Department of Necmettin Erbakan University Medical Faculty in between January and June 2020 . The flowchart of the study is shown in Figure 1.

Measurement protocol

Position and movement sense tests were used in the measurement of proprioception. Internal and external rotation movement directions while shoulder in 90 degree abduction are the most reliable aspects in the evaluation of shoulder proprioception using an isokinetic dynamometer . Therefore the tests were applied to the GHJ in internal and external rotation (2). Before taking the measurements, the system was calibrated according to the manufacturer's instructions and recommendations. The methodology of the study was explained in detail to each subject before the measurements and instructions were given of how to communicate with the researcher (14). Before the tests, each subject warmed up for 5 minutes with active joint range of movement exercises (18). Following the warm-up period, the subject was positioned supine over the isokinetic dynamometer. To reduce sensorial input, a pneumatic splint was applied to the dominant upper extremity, and the arm was then placed on the dynamometer with the elbow in 90° flexion and the shoulder in 90° abduction. Visual and auditory input was eliminated with the use of a blindfold and earplugs (6,14,19).

Position Sense Measurement

The upper extremity was moved passively from a neutral position in the direction of internal and external rotation as far as the reference angle. It was kept at the reference angle for 10 seconds and then passively moved back to the neutral position and rested for 10 secs. The subject was then instructed to repeat the position into which the upper extremity had been placed previously, taking the reference angle into consideration. The measurement was repeated 5 times for each reference angle, two of them were learning trials, the value of three test trials were recorded as the position sense test result. The measurement was taken for 4 reference angles: 30° internal rotation, 60° internal rotation, 30° external rotation, and 60° external rotation.

Movement Sense Measurement

The dynamometer moved the extremity in the direction of internal and external rotation at 0.1°/ sec. The subjects were instructed to tell the rater at the moment they first felt the movement. The time from the start of the test to the moment at which the subject felt the movement was recorded in secs. The measurements were taken in the following positions and directions: to internal rotation from 0°, to further internal rotation from 30° internal rotation, to external rotation from 0°, and to further external rotation from 30° external rotation. The measurement was repeated 5 times for each direction, two of them were learning trials, the value of three test trials were recorded as the movement sense test result.

Statistical Analysis

For position sense, the angular error was calculated, using the 3 different methods of absolute angular error (AAE), constant angular error (CAE) and variable angular error (VAE). The angular error averages obtained with each method were analyzed statistically. The mean values were calculated for the movement sense measurement results and were compared. Data were analyzed using SPSS for Windos vn. 21 (SPSS Inc., Chicago, IL, USA). A value of $p<0.05$ was accepted as statistically significant.

For intra-rater test reliability, the results of the same rater were used, and for inter-rater test reliability, the results of the two raters. The intra-rater and inter-rater reliability was determined with the interclass correlation coefficient (ICC). The ICC was calculated separately for each angle measured, using a 2-way random model in a 95% confidence interval. Reliability according to the ICC was interpreted as low (<0.40), moderate-good (0.40-0.75), or excellent (>0.75). In the determination of intra-rater and inter-rater test agreement, Bland-Altman plots were used. Standard error measurement (SEM) and minimal detectable change (MDC) values were also calculated as they provide information about both reliability and agreement.

RESULTS

Position sense

The mean angular error values are given in Table 1. The different mean error types calculate for position sense were in the range of 0.02±1.62 to 5.42±1.74.

Intratester reliability and agreement of position sense are given in Table 2. The ICC values of the intra-rater tests ranged between 0.038 and 0.657. The SEM values of the intra-rater tests were found to be in the range of 0.368-3.009. The LOA values of the intra-rater tests were in the range of 0.071 – 0.565. The MDC values ranged from 1.019 to 8.341.

Intertester reliability and agreement of position sense are given in Table 3. The ICC values of the inter-rater tests ranged between 0.095 and 0.779. The SEM values of the inter-rater tests were found to be in the range of 0.292-2.242. The LOA values of the inter-rater tests were in the range of 0.012 – 0.718. The MDC values ranged from 0.81 to 6.215. Movement sense

The mean values of the movement sense tests are given in Table 1. The movement sense test results of different directions and angles were in the range of 9.61±2.61 to 11.18±2.89.

Table 1. Angular Error and Movement Sense Mean Values

			Rater 1	**Rater 1**	**Rater 2**
		Variable	Mean±SD	Mean±SD	Mean±SD
Position sense	AAE	30˚ IR	2.16±0.53	2.31±0.72	2.38 ±0.69
		60˚ IR	2.14±0.56	2.26±0.56	2.33 ±0.77
		30˚ER	2.34±0.49	2.44±0.45	2.42 ±0.42
		60˚ ER	2.53±0.59	2.6±0.55	2.53 ±0.44
	CAE	30˚ IR	0.07±1.56	-0.35±1.84	-0.45 ±1.57
		60˚ IR	-0.89±1.36	-0.33±1.57	-0.31 ±1.56
		30˚ER	0.53±1.65	0.34±2.06	-0.02 ±1.62
		60˚ ER	-0.29±2.07	-0.15±1.84	0.55 ±1.5
	VAE	30˚ IR	4.6±1.71	4.49±1.98	4.89 ±2.05
		60˚ IR	4.39±1.56	4.92±1.76	4.99 ±1.98
		30˚ER	4.75±1.31	4.47±1.24	5.19 ±1.12
		60˚ ER	4.7±1.38	5.1±1.86	5.42 ±1.74
Movement sense		30˚ IR	11.18±2.89	11±3.32	10.14 ±4.16
60˚ IR		9.8±3.48	9.9±2.38	9.63 ±3.02	
30˚ER		10.88±3.15	10.65±2.9	11.02 ±4.27	
60˚ ER		9.65±3.29	9.61±2.61	9.59 ±2.9	

AAE: Absolute angular error, CAE: Constant angular error, VAE: Variable angular error, tests were in the range of 0.071 – 0.565. The MDC values ranged from 1.019 to 8.341.

Table 2. Intratester Reliability and Agreement

		Variable	ICC	SEM	MDC	Mean difference (LOA)
PS	AAE	30° IR	0.657(0.068,0.875)	0.368	1.019	-0.141 (-1.402-1.12)
		60° IR	0.535(-0.291,0.832)	0.384	1.063	-0.118 (-1.365-1.13)
		30°ER	0.358(-0.827,0.77)	0.378	1.047	-0.094(-1.255-1.066)
		60° ER	0.217(-1.325,0.723)	0.502	1.392	-0.071 (-1.55-1.409)
	CAE	30° IR	0.591(-0.147,0.853)	1.087	3.014	0.282 (-3.348-3.912)
		60° IR	-0.16(-2.217,0.581),	1.573	4.361	-0.565 (-4.774-3.644)
		30°ER	0.487(-0.482,0.817)	1.329	3.682	0.188 (-4.107-4.483)
		60° ER	-0.038(-2.219,0.638)	1.988	5.51	-0.141 (-5.606-5.324)
	VAE	30° IR	0.586(-0.193,0.852)	1.188	3.293	0.105 (-3.867-4.078)
		60° IR	0.362(-0.717,0.767)	1.327	3.679	-0.526 (-4.597-3.544)
		30°ER	-0.286(-2.965,0.551)	1.444	4.003	0.277 (-3.459-4.013)
		60° ER	-2.441(-11.225,-0.153)	3.009	8.341	-0.4 (-5.998-5.198)
MS		30° IR	0.687(0.108,0.888)	1.739	4.82	0.176 (-5.874-6.227),
60° IR		0.812(0.471,0.932)	1.271	3.523	-0.098 (-4.842-4.646)	
30°ER		0.912(0.757,0.968)	0.899	2.492	0.235 (-3.205-3.675)	
60° ER		0.891(0.695,0.961)	0.974	2.7	0.039 (-3.699-3.777)	

PS: Position sense, MS: Movement Sense, AAE: Absolute angular error, CAE: Constant angular error, VAE: Variable angular error, SEM:Standard error measurment, MDC: Minimal detectable change

Intratester reliability and agreement of movement sense are given in Table 2. The ICC values of the intra-rater tests ranged between 0.687 and 0.912. The SEM values of the intra-rater tests were found to be in the range of 0.899-1.739. The LOA values of the intra-rater tests were in the range of 0.039 – 0.235. The MDC values ranged from 2.492 to 4.82.

Intertester reliability and agreement of movement sense are given in Table 3. The ICC values of the inter-rater tests ranged between 0.844 and 0.925. The SEM values of the inter-rater tests were found to be in the range of 0.993-1.085. The LOA values of the inter-rater tests were in the range of 0.02 – 0.863. The MDC values ranged from 2.752 to 3.008.

DISCUSSION

The aim of this study was to evaluate the intra-rater and inter-rater reliability of the GHJ position and movement sense tests measured with an isokinetic dynamometer. The intra-rater and inter-rater reliability of the internal rotation position sense tests was at a moderate-good level. The external rotation intra-rater test reliability was determined to be weak, and the inter-rater reliability was moderate-good. In contrast, the intra-rater and inter-rater reliability of the movement sense tests was determined to be excellent.

To the best of our knowledge, intra-rater and inter-rater reliability has not yet been investigated in GHJ position sensing measurements made with isokinetic dynamometer in different populations in the literature. The studies cited on this subject are based on the study by Droun et al, which evaluated the mechanical reliability of the isokinetic dynamometer in the measurement of position, isometric torque and rate. However, it is not possible to explain the intra-rater and inter-rater reliability of the joint position sense measurement of the isokinetic dynamometer with these data (20). Nevertheless, research has been conducted on the intra-rater and inter-rater reliability of different measurement methods and tools used for shoulder girdle proprioception. Dover et al reported excellent intra-rater and inter-rater test reliability of the inclinometer for GHJ internal and external position sense measurement (21). In the measurement of position sense of low flexion angles, Vafadar et al reported that the inclinometer and laser pointer had excellent, and the goniometer had moderate-good intra-rater and inter-rater test reliability. It was also shown that the intra-rater and inter-rater test

Table 3. Intertester Reliability and Agreement

		Variable	ICC	SEM	MDC	Mean difference (LOA)
PS	AAE	30˚ IR	0.779(0.383,0.92)	0.331	0.917	-0.071 (-1.262-1.121)
		60˚ IR	0.518(-0.387,0.828)	0.463	1.284	-0.071 (-1.595-1.454)
		30˚ER	0.557(-0.286,0.842)	0.292	0.81	0.012 (-0.953-0.977),
		60˚ ER	0.6(-0.127,0.856)	0.311	0.862	0.071 (-0.975-1.116),
	CAE	30˚ IR	0.348(-0.934,0.769)	1.38	3.825	0.094 (-4.153-4.341)
		60˚ IR	0.293(-1.116,0.751)	1.313	3.639	-0.024 (-3.982-3.935)
		30˚ER	-0.095(-2.302,0.615)	1.925	5.336	0.365 (-4.88-5.61)
		60˚ ER	0.447(-0.41,0.793)	1.24	3.436	-0.706 (-4.587-3.175)
	VAE	30˚ IR	0.493(-0.421,0.817)	1.433	3.973	-0.395 (-4.995-4.205)
		60˚ IR	0.533(-0.357,0.834)	1.279	3.546	-0.072 (-4.263-4.119)
		30˚ER	-0.194(-1.97,0.55)	1.288	3.57	-0.718 (-4.148-2.712)
		60˚ ER	-0.554(-4.119,0.469)	2.242	6.215	-0.321 (-5.797-5.156)
MS		0˚ IR	0.925(0.782,0.973)	1.024	2.838	0.863 (-2.797-4.523),
30˚ IR		0.848(0.58,0.945)	1.054	2.922	0.275 (-3.661-4.21)	
0˚ER		0.923(0.792,0.972)	0.993	2.752	-0.373 (-4.23-3.485)	
30˚ ER		0.844(0.563,0.944)	1.085	3.008	0.02 (-4.031-4.07)	

PS: Position sense, MS: Movement Sense, AAE: Absolute angular error, CAE: Constant angular error, VAE: Variable angular error, SEM: Standard error measurment, MDC: Minimal detectable change

reliability was low in the measurement of position sense of mid and end angles of flexion (22). According to the inter-rater AAE ICC values found in the current study, the isokinetic dynamometer was seen to have a moderate-good level of inter-rater reliability in the measurement of position sense in mid and end (close to end) angles of both external and internal rotation of the GHJ. Furthermore, according to the intra-rater AAE ICC results, while the isokinetic dynamometer showed moderate-good intra-rater reliability for position sense in GHJ internal rotation, there was seen to be low reliability for external rotation. There are some difficulties in the comparison of these results with those of the studies by Dover et al. and Vafadar et al., as the test protocol, measurement position and directions tested are different (21,22). Nevertheless, in a rough comparison, it can be said that the current study results of the isokinetic dynamometer in the measurement of the GHJ position sense measurement provided more reliable results than those of the studies by Dover et al. and Vafadar et al. In another study by Ager et al., GHJ internal and external rotation position sense reliability was reported to be 0.83-0.98. However, that study by Ager et al. was a systematic review and the results do not represent a single method and/or a single subject profile, because weighted averages were calculated using the results of all the studies which met the inclusion criteria (2). Therefore, the results of the current study are not consistent with those of the study by Ager et al.

When AAE is taken into consideration, although the inter-rater test results were better, the LOA and SEM results can be interpreted as good for both intra-rater and inter-rater. These results showed that GHJ internal and external rotation position sense measurements with isokinetic dynamometer were repeatable, and there was high consistency between the repeated measurement results. According to the current study results, when AAE was taken into consideration, both the intra-rater and inter-rater LOA values were seen to be in a narrow range, and the inter-rater LOA values were in a narrower range than those of the intra-rater test LOA values. These LOA results demonstrated that the isokinetic dynamometer was sensitive for the measurement of GHJ internal and external rotation position sense, and small changes could be detected. Furthermore, this was supported by the MDC values found in the range of 0.810-1.392. In other words it can be said that the isokinetic dynamometer can detect GHJ external and internal rotation position sense up to approximately one degree. No research could be found in literature that has presented similar data related to GHJ external and internal rotation position sense of the isokinetic dynamometer or any other measurement tool. MDC values of 1.8 – 5 for shoulder flexion have been reported obtained with inclinometer, laser pointer and goniometer (22). Even when compared with these values, the isokinetic dynamometer can be predicted to provide more sensitive results than other tools in the measurement of position sense.

As position sense measurement results are affected by several factors such as environmental conditions and the learning curve, the reliability of the test is limited (2,23). This is reflected in the conflicting results of position sense reliability values reported in different studies. Although compared with other measurement tools, when the current study results are evaluated together with the findings in literature, the isokinetic dynamometer can be seen to be a good option for the measurement of GHJ internal and external rotation position sense. Moreover, the satisfactory results related to the consistency values such as SEM and LOA, increase the power of repeatability of the test and eliminate some of the concerns about reliability. In addition, the low LOA range and MDC values supporting the ability to detect small changes show that the isokinetic dynamometer should be used in situations where a sensitive measurement is required.

To the best of our knowledge, the reliability of the GHJ motion sense test alone has not yet been investigated in any population in the literature. In the systematic review by Ager et al, the intra-rater and inter-rater reliability of the movement sense test used in the measurement of shoulder proprioception was reported to be excellent (ICC =0.92 for both inter-rater and intra-rater) (2). However, the reliability value resulting from that study was calculated from the weighted averages of the findings of all the studies included in the review regardless of the study populations and/or which measurement tools were used. Therefore, the results do not reflect the reliability of any method and/or measurement tool. When compared with the results of the current study, although no information is provided about the reliability of the isometric dynamometer alone, the current study results seem to be supported by the reliability results reported by Ager et al.

The LOA and SEM results related to movement sense in the current study showed the repeatability of the GHJ internal and external rotation movement sense tests made with the isokinetic dynamometer and there was extremely good agreement between the repeated measurements. Furthermore, the narrow LOA range and low MDC values showed that the test was sensitive in the determination of small changes.

The movement sense test is known to be more reliable than the position sense test in the evaluation of proprioception (13). This is because the movement sense test better represents the afferent proprioceptive sensory process and better reveals the contribution of passive structures to the process (12). However, the ecological validity of the movement sense test is limited compared to the position sense test (24). Thus, this test alone may be insufficient to reflect proprioception and to determine small changes between the performances of an individual (25,26). Consistent with findings in literature, the current study results show that the intra-rater and inter-rater reliability of the movement sense test is higher than that of the position sense test.

The results related to movement sense show that the isokinetic dynamometer is reliable and consistent in the evaluation of the GHJ internal and external rotation movement sense test, with high repeatability and is a tool that can be used in the determination of small deviations.

The reliability of the isokinetic dynamometer in the measurement of GHJ proprioception in different patient groups could be investigated in future studies. There is also a need for studies to compare the efficacy of the inclinometer, laser pointer, and movement analysis systems with the isokinetic dynamometer in the measurement of GHJ proprioception.

The main limitation which could be thought to affect the current study results was the low number of participants. It has been previously reported that there should be at least 50 participants in reliability studies (27). Therefore, although the results of this pilot study conducted in healthy individuals provide important information for the general population, it cannot be recommended to generalize the results of the study for subgroups. However, in the future it can be considered that repeating this study with a high number of participants would increase the reliability, especially of the position sense test results.

CONCLUSION

The results of the GHJ position sense and movement sense tests obtained using the isokinetic dynamometer showed a high level of intra-rater and inter-rater agreement. Moreover, the isokinetic dynamometer is a good measurement tool for the determination of small changes in the GHJ internal and external rotation position sense and movement threshold. In addition, current study showed that the movement sense measurements made with the isokinetic dynamometer are more reliable than the position sense measurements.

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REFERENCES

1. Hillier S, Immink M, Thewlis D. Assessing proprioception: a systematic review of possibilities. Neurorehabil Neural Repair. 2015;29(10):933-49. https://doi.org/10.1177/1545968315573055
2. Ager AL, Roy JS, Roos M, Belley AF, Cools A, Hébert LJ. Shoulder proprioception: how is it measured and is it reliable? A systematic review. J Hand Ther. 2017;30(2):221-31. https://doi.org/10.1016/j.jht.2017.05.003
3. Tuthill JC, Azim E. Proprioception. Curr Biol. 2018;28(5):194-203. https://doi.org/10.1016/j.cub.2018.01.064
4. Aman JE, Elangovan N, Yeh I, Konczak J. The effectiveness of proprioceptive training for improving motor function: a systematic review. Front Hum Neurosci. 2015;8:1075. https://doi.org/10.3389/fnhum.2014.01075
5. Cappellino F, Paolucci T, Zangrando F, Iosa M, Adriani E, Mancini P, et al. Neurocognitive rehabilitative approach effectiveness after anterior cruciate ligament reconstruction with patellar tendon. A randomized controlled trial. Eur J Phys Rehabil Med. 2012;48(1):17-30.
6. Miller AH, Evans K, Adams R, Waddington G, Witchalls J. Shoulder injury in water polo: A systematic review of incidence and intrinsic risk factors. J Sci Med Sport. 2018;21(4):368-377. https://doi.org/10.1016/j.jsams.2017.08.015
7. Marzetti E, Rabini A, Piccinini G, Piazzini DB, Vulpiani MC, Vetrano M, et al. Neurocognitive therapeutic exercise improves pain and function in patients with shoulder impingement syndrome: a single-blind randomized controlled clinical trial. Eur J Phys Rehabil Med. 2014;50(3):255-64.
8. Fyhr C, Gustavsson L, Wassinger C, Sole G. The effects of shoulder injury on kinaesthesia: a systematic review and meta-analysis. Man Ther. 2015;20(1):28-37. https://doi.org/10.1016/j.math.2014.08.006
9. Gumina S, Camerota F, Celletti C, Venditto T, Candela V. The effects of rotator cuff tear on shoulder proprioception. Int Orthop. 2019;43(1):229-35. https://doi.org/10.1007/s00264-018-4150-1
10. Contemori S, Biscarini A, Botti FM, Busti D, Panichi R, Pettorossi VE. Sensorimotor control of the shoulder in professional volleyball players with isolated infraspinatus muscle atrophy. J Sport Rehabil. 2018;27(4):371-9. https://doi.org/10.1123/jsr.2016-0183
11. Ager AL, Borms D, Deschepper L, Dhooghe R, Dijkhuis J, Roy JS, et al. Proprioception: How is it affected by shoulder pain? A systematic review. J Hand Ther. 2020;33(4):507-16. https://doi.org/10.1016/j.jht.2019.06.002
12. Langer L, Osborne R, Rowe RH, Beneciuk JM. Laser testing for upper extremity proprioceptive deficits following rotator cuff injury: two case reports. Physiother Theory Pract. 2020;36(12):1493-501. https://doi.org/10.1080/09593985.2019.15711141
13. Lin YL, Karduna A. Errors in shoulder joint position sense mainly come from the glenohumeral joint. J Appl Biomech. 2017;33(1):32-8. https://doi.org/10.1123/jab.2016-0034
14. Fabis J, Rzepka R, Fabis A, Zwierzchowski J, Kubiak G, Stanula A, et al. Shoulder proprioception–lessons we learned from idiopathic frozen shoulder. BMC Musculoskelet Disord. 2016;17(1):1-8. https://doi.org/10.1186/s12891-016-0971-5
15. Dilek B, Gulbahar S, Gundogdu M, Ergin B, Manisali M, Ozkan M, et al. Efficacy of proprioceptive exercises in patients with subacromial impingement syndrome: a single-blinded randomized controlled study. Am J Phys Med Rehabil. 2016;95(3):169-82. https://doi.org/10.1097/PHM.0000000000000327
16. Vafadar AK, Côté JN, Archambault PS. Sex differences in the shoulder joint position sense acuity: a cross-sectional study. BMC Musculoskelet Disord. 2015;16(1):1-7. https://doi.org/10.1186/s12891-015-0731-y
17. Uysal SA, Ekinci Y, Çoban F, Yakut Y. Edinburgh el tercihi anketi Türkçe güvenirliğinin araştırılması. JETR. 2019;6(2):112-8.
18. Morgan R, Herrington L. The effect of tackling on shoulder joint positioning sense in semi-professional rugby players.

Phys Ther Sport. 2014;15(3):176-80. https://doi.org/10.1016/j.ptsp.2013.10.003

19. Sole G, Osborne H, Wassinger C. The effect of experimentally-induced subacromial pain on proprioception. Man Ther. 2015;20(1):166-70. https://doi.org/10.1016/j.math.2014.08.009
20. Drouin JM, Valovich-mcLeod TC, Shultz SJ, Gansneder BM, Perrin DH. Reliability and validity of the Biodex system 3 pro isokinetic dynamometer velocity, torque and position measurements. Eur J Appl Physiol. 2004;91(1):22-9. https://doi.org/10.1007/s00421-003-0933-0
21. Dover G, Powers ME. Reliability of joint position sense and force-reproduction measures during internal and external rotation of the shoulder. J Athl Train. 2003;38(4):304.
22. Vafadar AK, Côté JN, Archambault PS. Interrater and intrarater reliability and validity of 3 measurement methods for shoulder-position sense. J Sport Rehabil. 2016;25(1): 2014-0309. https://doi.org/10.1123/jsr.2014-0309
23. Relph N, Herrington L. Criterion-related validity of knee joint-position-sense measurement using image capture and isokinetic dynamometry. J Sport Rehabil. 2015;24(1): 2013-0119. https://doi.org/10.1123/jsr.2013-0119
24. Han J, Waddington G, Adams R, Anson J, Liu Y. Assessing proprioception: a critical review of methods. J Sport Health Sci. 2016;5(1):80-90. https://doi.org/10.1016/j.jshs.2014.10.004
25. Elangovan N, Herrmann A, Konczak J. Assessing proprioceptive function: evaluating joint position matching methods against psychophysical thresholds. Phys Ther. 2014;94(4):553-61. https://doi.org/10.2522/ptj.20130103
26. Boerboom AL, Huizinga MR, Kaan WA, Stewart RE, Hof AL, Bulstra SK, et al. Validation of a method to measure the proprioception of the knee. Gait Posture. 2008;28(4):610-4. https://doi.org/10.1016/j.gaitpost.2008.04.007
27. Rankin G, Stokes M. Reliability of assessment tools in rehabilitation: an illustration of appropriate statistical analyses. Clin Rehabil. 1998 Jun;12(3):187-99. https://doi.org/10.1191/026921598672178340