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TECHNICAL REPORT

Test–Retest Reliability of Isokinetic Wrist Strength and Proprioception Measurements

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Context: The evaluation of the wrist strength and proprioception gives clinicians and researchers information about effectiveness of their rehabilitation protocol or helps diagnosis of various neuromuscular and somatosensorial disorders. Isokinetic dynamometers are considered the gold standard for these evaluations. However, the studies about test–retest reliability of isokinetic dynamometer are inadequate. ***Objective:*** The purpose of this study was to determine the test–retest reliability of isokinetic wrist strength and proprioception measurements using the Cybex isokinetic dynamometer. ***Design:*** Test–retest reliability study. ***Setting:*** University laboratory. ***Participants:*** Thirty participants were enrolled (age 23.2 [2.8] y, height 171.1 [7] cm, weight 66.6 [11.6] kg) in this study. ***Intervention:*** Cybex isokinetic dynamometer was used for strength and proprioception measurements. ***Main Outcome Measures:*** Concentric flexion–extension strength test was performed at 90°/s angular velocity, and eccentric flexion–extension strength test was performed at 60°/s angular velocity. The proprioception of the wrist was assessed via active joint position sense. The 30° extension of the wrist, which is accepted as the functional position of the wrist, was selected as the targeted angle. The intraclass correlation coefficient ($ICC_{2,1}$) method was used for test–retest analysis ($P < .05$). ***Results:*** The active joint position sense measurements of dominant ($ICC_{2,1}$: .821) and nondominant ($ICC_{2,1}$: .763) sides were found to have good test–retest reliability. Furthermore, with the exception of dominant eccentric extension strength (moderate reliability) ($ICC_{2,1}$: .733), eccentric and concentric flexion (dominant: $ICC_{2,1}$ = .890–.844; nondominant: $ICC_{2,1}$ = .800–.898, respectively), and extension (dominant: $ICC_{2,1}$ = .791 [concentric], nondominant: $ICC_{2,1}$ = .791–.818, respectively) strength measurements of both sides were found to have good reliability. ***Conclusions:*** This study shows that the Cybex isokinetic dynamometer is a reliable method for measuring wrist strength and proprioception. Isokinetic dynamometers can be used clinically for diagnosis or rehabilitation in studies which contain wrist proprioception or strength measurements.

Keywords: position sense, muscle strength, rehabilitation, disability evaluation, diagnostic techniques, procedures

Proprioception is defined as being aware of body position in space. Impulses that come from muscles, tendons, joint capsules, and skin compose proprioception. The afferent information, which comes from these areas, is important for motor performance to be effective and safe.[1] A good proprioception sense can provide better function and decrease the risk and incidence of injuries.[2] If the deficit of proprioception sense is noticed beforehand, possible injuries can be avoided thanks to proprioceptive exercise program.[3]

The evaluation of the wrist strength and proprioception gives clinicians and researchers information about effectiveness of their rehabilitation protocol or helps diagnosis of various neuromuscular and somatosensorial disorders.[4,5] One of the frequently used methods is manual muscle testing because it is easy and fast to use in clinics. However, it is a subjective assessment and accurate measurement is not possible. Another frequently used evaluation method is with a hand-held dynamometer. However, some specialties of raters such as gender, body weight, and grip strength affect a rater's reliability in obtaining torque measurements.[6] Isokinetic dynamometers are known as a reliable method and are accepted as the gold standard by virtue of the fact that an accurate measurement can be obtained and the effect of the person performing the assessment is minimum.[7] Isokinetic dynamometer is a device which provides the recording of the torques in all degrees in changeable velocities and can be used for measurement of agonist–antagonist strength.[8] In literature, there are some studies that have used isokinetic dynamometers for wrist strength measurement.[9–11] However, the number of the studies regarding test–retest reliability of isokinetic dynamometer is inadequate.

The reliability of the isokinetic dynamometer is important because it gives clinicians information about whether there is a change in the results of the patient's measurements via the precise assessments performed. The reliability depends on the consistency of results and is based on the low error rate or absence of error of all kinds in measurements. The test–retest reliability of measurement is essential, especially for treatment or research that contains long-term follow-up. In literature, there is a limited number of studies examining the test–retest reliability of concentric strength measurement of wrist, but no study investigating the reliability of wrist eccentric strength or proprioception measurement using an isokinetic dynamometer was found.[12] The purpose of this study was to determine the test–retest reliability of isokinetic wrist strength and proprioception measurements using the Cybex isokinetic dynamometer.

Methods

Participants

According to the statistical power analysis performed with G*Power 3.1 (Franz FAUL, Kiel, Germany) power analysis program, 30 participants were necessary to obtain 95% power. Thus,

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this study was conducted with 30 healthy young voluntary participants (15 men and 15 women, age 18–30 y; dominant side: right = 26, left = 4). The demographic characteristics of the participants are presented in Table 1. Subjects who had pain, a joint injury, undergone surgery, or neuromuscular dysfunction were excluded from the study. There are many studies stating that the menstrual cycle does not affect muscle performance and proprioception; therefore, the female participants' menstrual cycles were not questioned.[13,14] Informed consent was obtained from all participants before the study was conducted. The study was approved by an independent ethics committee.

Instrumentation

Cybex isokinetic dynamometer (Cybex NORM®; Humac, CA, Computer Sports Medicine, Inc., Stoughton, MA) was used for wrist flexion and extension strength and proprioception measurements. The device was calibrated per the manufacturer's specifications and was verified prior to testing.

Procedures

Before initiating the assessments, the subjects' name-surname, gender, birthdate, height, weight, and dominant side were entered into the system. Strength and proprioception measurements were performed with the elbow at 90° flexion, wrist in full supination, with the participant in a sitting position (Figure 1). The dynamometer's rotation axis was aligned with the diagonal axis of the radius' distal tuberculum and head of the ulna (HUMAC norm, model 502140; Computer Sports Medicine, Inc, Stoughton, MA).

Table 1 Demographic Characteristics of the Participants

Age, y	23.2 (2.8)
Height, cm	171.1 (7)
Weight, kg	66.6 (11.6)
BMI, kg/m^2	22.6 (2.6)

Abbreviation: BMI, body mass index.

During the measurements, the position of the participants' elbow joint was elbow flexion of 90°, and the forearm was stabilized with a strap. Therefore, the biceps and triceps muscles were immobilized, so they did not have any effect on wrist movements (Figure 2).[15] The wrist was adjusted to 0° position with a goniometer. This position was saved to the dynamometer as 0° position. The points which the dynamometers' apparatus was at 0° position for the wrist of each participant were noted and were used in the second assessment. At this position, in order to prevent excessive wrist movements, the range of motion of the dynamometer was set at a total of 80°; 40° of wrist flexion and 40° wrist extension as described by Ellenbecker et al.[16]

Prior to testing, in order to achieve standardization, the devices' gravity compensation was activated. In this way, during the assessments, the effect of gravity effect was eliminated. In addition, the participants were informed on maintaining their trunk position during the assessments. Before initiating the assessments, the participants were taught how the assessments were performed. Three repeated trials (in a submaximal manner) were performed before the assessments as a warm-up and for familiarization of each test. The parameters used in the trials were the same as the assessment and were not performed with maximal effort. After the trials, a 20-second resting time was provided.

Angular velocity adjustment depends on the joint and parameter evaluated.[17] Strength tests are performed at low speeds, while power and endurance tests are performed at high velocities.[18] These angular velocities are generally classified as low, 30 to 60°/s; medium, 90 to 120°/s; and high, 180 to 300°/s. The ability of a muscle to produce concentric force is highest at low speeds and decreases linearly with increasing test speed.[17] In addition, it is stated that eccentric contraction is not safe at low angular velocities, but the angular velocities at 90°/s are well tolerated.[15] Therefore, concentric flexion–concentric extension strength test was performed at 90°/s angular velocity with 5 repetitions, and eccentric flexion–eccentric extension strength test was performed at 60°/s angular velocity with 5 repetitions. Between each test, a resting time of 60 seconds was given. During the first and second measurements, the same visual and verbal conditions were provided for all participants. Both wrists flexion and extension peak torques were measured at 60°/s concentric mode and at 90°/s

Figure 1 — The participant position for measurements

Figure 2 — The wrist position for measurements

eccentric mode. In addition, for each wrist, the peak torque rates for unilateral extension/flexion were calculated at both angular velocities.

Wrist proprioception was evaluated as active joint position sense (AJPS). To prevent visual input, all subjects wore eye masks during the testing. The 30° extension that is the functional position of the wrist was selected as the target angle.[19] In order to establish familiarization, we limited dynamometer range between 30° extension and 0°; then we wanted subjects to learn the target angle starting with neutral position (0°) and wait 5 seconds at the target position. Thanks to gravity compensation, the participants did not have to make any contractions while waiting at the target angle. Participants were taught the target angle 3 times. After that, we removed the 30° limit and asked them to reproduce the target angle as accurately as they could and return to the starting position 3 times, consecutively. The difference between the angle sensed by the participants and target angle was recorded as the absolute angular error. The relative angular error (RAE) was calculated as the arithmetic mean of the absolute angular errors.[20]

$$\mathrm{RAE} = [|(\text{target angle} - \text{first trial})| + |(\text{target angle} - \text{second trial})| + |(\text{target angle} - \text{third trial})|]/3.$$

The same measurements were repeated 7 days later as stated in previous studies.[21] The second measurement was performed at the same time of day to avoid the effect of diurnal variation. All measurements were performed by the same person to prevent interrater variability.

In the first assessments made, in order to prevent the learning effect, we randomly chose whether to start with the right or left wrist and also whether to start with strength or proprioception assessment. The order of measurements was recorded for each participant and was used again during the second measurements.[22] In order to avoid the effects of fatigue on AJPS test, 5 minutes resting time was given after strength assessments.

Statistical Analysis

Statistical analysis was performed using the SPSS (version 22; IBM, Armonk, NY) computer software system. The intraclass correlation coefficient ($\mathrm{ICC}_{2,1}$) method was used for test–retest analysis. Statistical significance for this study was based on the $P < .05$ level. The $\mathrm{ICC}_{2,1}$ values were defined as: higher than .90 was excellent, .75 to .90 was good, .50 to .75 was moderate, and less than .50 was poor.[23] SEM was calculated to inspect the measurement error of the dynamometer. Sensitivity was examined by minimal detectable change (MDC) (95% confidence interval). For calculations of SEM and MDC, the following formulas were used.[20,24]

$$\mathrm{SEM} = \mathrm{SD} \times \sqrt{1 - \mathrm{ICC}} \quad \text{and} \quad \mathrm{MDC} = \mathrm{SEM} \times \sqrt{2} \times 1.96.$$

Results

Mean and SD of first and second AJPS and strength measurements of dominant and nondominant sides are presented in Table 2.

The statistical analysis showed that the AJPS measurements of the dominant (ICC: .821) and nondominant (ICC: .763) sides were found to have good test–retest reliability. Also, it was found that the concentric and eccentric flexion strength measurements of both the dominant and nondominant sides had good reliability. Furthermore, with the exception of dominant eccentric extension strength, all concentric and eccentric extension strength measurements of both sides were found to have good reliability. When extension/flexion peak torque rates were examined, all peak torque rates of dominant and nondominant sides strength measurements were found to have moderate reliability (Table 3).

Discussion

The main finding of this study is that the isokinetic dynamometer has been shown to be a reliable method in measuring proprioception and concentric strength at 90°/s and eccentric strength at 60°/s. In addition, using the isokinetic dynamometer is a reliable way to investigate extension/flexion peak torque rates of strength measurements at both angular velocities.

It is shown that a good proprioception sense can decrease the risk and incidence of injuries.[2] An objective proprioception measurement may give us information regarding the risk of injury. Although the test–retest reliabilities of proprioception measurements using isokinetic dynamometer were researched for many joints, we could not find any study about the wrist. According to our literature search, this study is important because it is the first study which investigates test–retest reliability of wrist proprioception measurement using isokinetic dynamometer. As illustrated in our results, the Cybex isokinetic dynamometer is a reliable tool for measurement of both dominant (ICC: .821) and nondominant (ICC: .763) wrist proprioception sense. In literature, there are some different methods which have test–retest reliability studies but none of them are as common as, or give objective results as much as isokinetic dynamometers.[5,25,26]

Table 2 Means and SDs of Measurements

		Dominant		Nondominant	
Angular velocity, °/s	Test	1. Measurement	2. Measurement	1. Measurement	2. Measurement
–	AJPS, deg	4.05 (2.66)	4.43 (2.82)	4.32 (2.39)	3.93 (2.87)
90	Con Flex, N·m	8.06 (3.82)	7.93 (3.31)	7.5 (2.62)	7.33 (2.6)
90	Con Ext, N·m	12.46 (5.65)	13.3 (5.49)	12.13 (4.68)	11.93 (4.27)
90	Con Ext/Flex PT rate	65.76 (14.82)	62.06 (15.26)	64.60 (13.97)	65.13 (15.22)
60	Ecc Flex, N·m	10.4 (4.69)	10.3 (4.79)	9.63 (3.6)	9.16 (4.07)
60	Ecc Ext, N·m	15.4 (6.64)	15.4 (5.75)	14.73 (5.2)	13.66 (4.27)
60	Ecc Ext/Flex PT rate	69.43 (11.50)	66.46 (14.99)	66.86 (15.10)	66.90 (14.59)

Abbreviations: AJPS, active joint position sense; Con, concentric; Ecc, eccentric; Ext, extension; Flex, flexion; N·m, Newton meter; PT, peak torque. Note: Values are given as mean and SD.

Table 3 ICC, SEM, and MDC Values of Measurements

Angular velocity, °/s	Test	ICC*	95% CI Lower bound	95% CI Upper bound	SEM	MDC	P
–	Dom AJPS	.821	.627	.914	1.12	3.10	<.001
–	Non-Dom AJPS	.763	.507	.887	1.16	3.21	<.001
90	Dom Con Ext	.791	.559	.901	1.74	4.82	<.001
90	Dom Con Flex	.844	.675	.925	2.23	6.18	<.001
90	Dom Con Ext/Flex PT rate	.577	.126	.797	9.64	26.72	.01
90	Non-Dom Con Ext	.818	.617	.914	1.12	3.10	<.001
90	Non-Dom Con Flex	.898	.785	.951	1.49	4.13	<.001
90	Non-Dom Con Ext/Flex PT rate	.540	.018	.783	9.47	26.25	.02
60	Dom Ecc Ext	.733	.434	.874	2.42	6.71	<.001
60	Dom Ecc Flex	.890	.767	.948	2.20	6.10	<.001
60	Dom Ecc Ext/Flex PT rate	.545	.054	.782	7.76	21.51	.02
60	Non-Dom Ecc Ext	.791	.563	.900	1.65	4.57	<.001
60	Non-Dom Ecc Flex	.800	.584	.904	2.32	6.43	<.001
60	Non-Dom Ecc Ext/Flex PT rate	.642	.238	.831	9	24.94	.004

Abbreviations: AJPS, active joint position sense; CI, confidence interval; Con, concentric; Dom, dominant; Ecc, eccentric; Ext, extension; Flex, flexion; ICC, intraclass correlation coefficient; MDC, minimal detectable change; Non-Dom, nondominant; PT, peak torque.

The wrist flexors are used repeatedly; therefore, they are prone to injury (tendinitis, tunnel syndromes, stress fractures, etc).[27] Isokinetic assessment provides determination of bilateral asymmetry and agonist–antagonist imbalance and assists in detecting these musculoskeletal injuries.[28] The reliability of the isokinetic dynamometer is essential for the correct interpretation of results.[12] Although there are many studies that use isokinetic dynamometer to measure wrist strength,[9–11] there are a limited number of studies on test–retest reliability of wrist strength measurement using isokinetic dynamometer. However, extension/flexion peak torque rate, eccentric measurement, and 90°/s angular velocity were not assessed in any of these studies. The 90°/s is one of the most used angular velocities in literature.[16,28,29] Therefore, we used this angular velocity. Xu et al[12] showed that isokinetic dynamometers are reliable tools for strength measurements at 60°/s and 180°/s angular velocities (ICC: .92–.94). Vanswearingen[30] reported that the ICC values of the isometric and concentric strength measurements of wrist flexion and extension at 60°/s angular velocity ranged from .643 to .986. A study conducted by Ng and Chan[31] on patients with lateral epicondylitis showed that the intrarater reliability of wrist isometric extension strength measurement at 120°/s angular velocity was found to be excellent (ICC: .99). The findings of these studies are similar to our results.

Researches show that the position of wrist affects the hand function.[32–34] One of the most important mechanisms involved in providing the optimal position of the wrist for a good function is proprioception. Proprioception studies have shown that proprioceptive training reduces the incidence of injury and provides more rapid and effective treatment of injuries.[35–38] Despite the importance of wrist position function and proprioception, there is no standard or approved test or tool in the literature to evaluate wrist proprioception.[39] Due to complex anatomic and biomechanical characteristic of the wrist, the risk of making mistakes is very high while performing measurements. A small mistake leads to wrong measurement results and accordingly, causes misinterpretations of the results. This may be one of the reasons why there is no standardized method of wrist proprioception evaluation. Isokinetic dynamometers can perform standardized measurement, give results as computer data and the rater effect is minimum during the measurements and therefore they are objective measurement tools and decrease the risk of mistakes.

The limitation of our study is that the concentric tests were performed only at 90°/s angular velocity. However, higher angular velocities which are used in endurance measurements could also be tested.

To our knowledge, the present study is the first to examine the reliability of the measurement of proprioception and eccentric strength during wrist flexion and extension. The 60°/s and 90°/s angular velocities are of the most used angular velocities in literature, but there is a need for similar studies that use other angular velocities.

Conclusions

We found that the Cybex isokinetic dynamometer is a reliable method used for measurements of wrist strength and proprioception. Also, the extension/flexion peak torque rate assessment has found to have moderate reliability.

We recommend using isokinetic dynamometers clinically and in studies which contain wrist proprioception or strength measurements.

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