Hand Surgery and Rehabilitation 41 (2022) 183–188

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Original article

Evaluation of the validity and reliability of the KFORCE Sens® electrogoniometer in evaluation of wrist proprioception

Évaluation de la validité et de la fiabilité de l'électrogoniomètre KFORCE Sens® dans l'évaluation de la proprioception du poignet

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A R T I C L E   I N F O

Article history:
Received 4 October 2021
Received in revised form 11 December 2021
Accepted 14 December 2021
Available online 30 December 2021

Keywords:
Position sense
Proprioception
Reliability
Validity
Wrist

A B S T R A C T

The aim of this study was to determine the validity and reliability of the KFORCE Sens® electrogoniometer in the evaluation of wrist proprioception. Wrist position sense was assessed on a Baseline® 360° universal goniometer and a KFORCE Sens® device. The validity and reliability of the KFORCE Sens® device for wrist position sense evaluation were investigated by comparing the two data sets. Fifty-three healthy volunteers (39 female, 14 male) with a mean age of 22.83 ± 1.28 years (range, 21–27 years) were included. Joint position sense test-retest reliability (intra-class correlation coefficient) on KFORCE Sens® was "very good" for all wrist movements. There was a very strong correlation between flexion–extension movements on the dominant side (r = 0.955), and a strong correlation between ulnar–radial deviation movements (r = 0.745). There was also a very strong (r = 0.863) correlation between flexion–extension movements on the non-dominant side and a strong correlation (r = 0.690) between ulnar–radial deviation movements ($p < 0.05$). Our results showed that the KFORCE Sens® device was a valid and reliable evaluation means of assessing wrist position sense.

Mots-clés:
Sens de la position
Proprioception
Fiabilité
Validité
Poignet

R É S U M É

Le but de cette étude était de déterminer la validité et la fiabilité du dispositif d'électrogoniométrie KFORCE Sens® dans l'évaluation du sens de la proprioception du poignet. L'évaluation du sens de la position du poignet des participants a été effectuée séparément avec le goniomètre universel Baseline® 360° et le KFORCE Sens®. La validité et la fiabilité du dispositif KFORCE Sens® dans l'évaluation du sens de la position du poignet ont été étudiées en comparant les données obtenues. Cinquante-trois participants en bonne santé (39 femmes, 14 hommes) d'un âge moyen de 22,83 ± 1,28 ans (min 21 ans, max 27 ans) ont été inclus dans l'étude sur une base volontaire. La fiabilité test-retest de tous les mouvements du poignet concernant le sens de la position articulaire réalisée avec KFORCE Sens était "très bonne" selon le coefficient de corrélation intra-classe (ICC). Il a été trouvé une très forte corrélation entre les mouvements de flexion–extension du côté dominant (r = 0,955), une forte corrélation entre les mouvements de déviation radio-ulnaire (r = 0,745). De plus, il y avait une corrélation très élevée (r = 0,863) entre les mouvements de flexion–extension et une corrélation élevée (r = 0,690) entre les mouvements de déviation radio-ulnaire (p < 0,05). Nos résultats montrent que le dispositif KFORCE Sens® est un dispositif d'évaluation valide et fiable pour l'évaluation du sens de la position du poignet.

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https://doi.org/10.1016/j.hansur.2021.12.006
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1. Introduction

Proprioception is the general term used for kinesthesia and joint position sense. Joint position sense refers more specifically to the awareness of joint position in space and relies on various receptors called mechanoreceptors [1], found in the joint capsule, ligaments, meniscus, musculotendinous units, and skin [2]. To assess joint position sense, universal goniometers are used, in addition to various proprioception evaluation devices and written evaluation scales [3,4].

With the development of technology, the use of electrogoniometers instead of universal goniometers has become widespread for range of motion measurement in physiotherapy and rehabilitation [5]. Validity and reliability studies have been conducted in the evaluation of proprioception using electrogoniometers in various joints [6,7]. Electrogoniometry is known to be a valid and safe tool to evaluate proprioception sensation in the ankle [8,9] and knee [5,10], but there have been few studies on the wrist [11,12].

KFORCE Sens® is an inertial sensor or electrogoniometer, developed by the biomechanical engineers of Kinvent™ (Montpellier, France) in 2017 to measure range of motion and compare the affected with the intact limb. It offers real-time biofeedback based on improvement in range of motion over initial values, using inertial measurement sensors. According to the technical specifications' manual, measurement accuracy is 1° and device deviation is 3°. The device can transfer the obtained data to a computer or smartphone via a Bluetooth® connection.[1]

The aim of this study was to determine the validity and reliability of the KFORCE Sens® electrogoniometer for the evaluation of wrist proprioception.

2. Materials and methods

The study was conducted on 53 healthy young adults aged 21–27 years. Approval for the study was obtained from the review board (meeting n° 24, December 21st, 2020). Prior written informed consent was obtained from all participants. The study was conducted in accordance with the Declaration of Helsinki.

2.1. Participants

Healthy young adult volunteers who met the inclusion criteria were included. Exclusion criteria comprised any orthopedic, neurological, rheumatological or metabolic disease involving the limbs, surgical history in the previous 6 months, occupation in

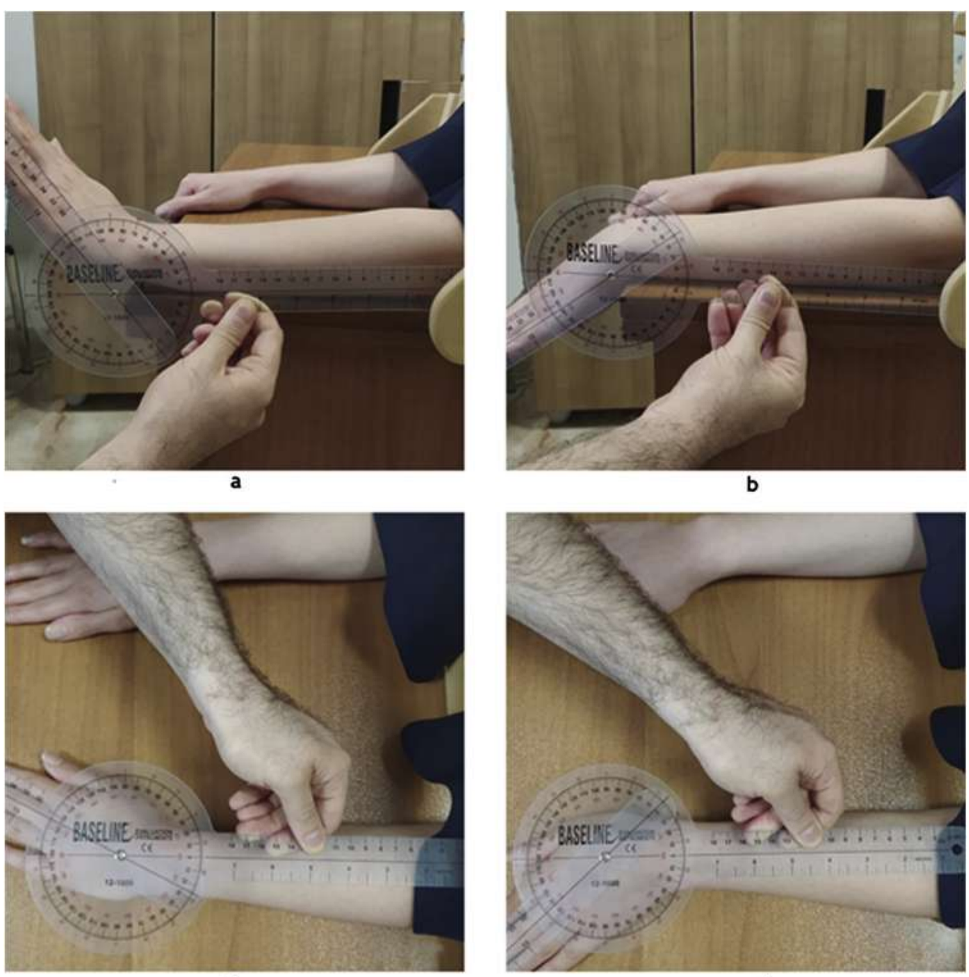

Fig. 1. Evaluation of position sense with universal goniometer. Extension (a), flexion (b), radial deviation (c) and ulnar deviation (d).

[1] Hellas K. KFORCE Products Manual (2020). Thessalonica: Stylianou Lykoudi

which only one of the upper extremities is used, and regular exercise program involving the upper extremity.

2.2. Study design

Wrist position sense was assessed on both a Baseline® 360° universal goniometer and KFORCE Sens®. KFORCE Sens® validity and reliability were investigated by comparing the two data-sets. All evaluations were made by a single physiotherapist (FT), so as to standardize evaluations.

Before evaluation, the protocol was explained to the participants and the device was introduced. Joint position sense was assessed on flexion–extension and ulnar–radial deviation. Evaluations were made in a quiet room, on a hand examination table, where the participant was alone with the physiotherapist, with no distraction. The limb was hidden from the subject by a screen throughout the evaluation process. Evaluation began with the dominant extremity. Two trial evaluations were first made, followed by a 1-min rest. Then evaluation was repeated 10 times, with a 10-second rest periods between each. (These repetition numbers and rest times were determined by the authors, as there is no standardized protocol in the current literature.)

Mean error was determined as the mean discrepancy between passive (reference) and active limb position per repetition. The lower the mean error, the better the subject's sense of joint position [12]. To avoid a learning effect, each participant was evaluated in different angles.

2.3. Evaluation of position sense

2.3.1. Universal goniometer

The limb was placed in 90° shoulder and elbow flexion and the forearm in pronation for flexion–extension measurements. The wrist was positioned so as to hang from the table; the pivot of the universal goniometer was placed on the styloid of the ulna (Fig. 1). To assess ulnar–radial deviation, the limb was placed in 90° shoulder and elbow in flexion and the forearm in pronation, with the wrist on the table; the pivot of the universal goniometer was placed on the third carpometacarpal joint. A passive movement of the limb was made with predetermined amplitude and direction. The participant was asked to remember the limb position at the end of the movement and, after the rest phase, to return the wrist to this position. The passive and voluntary positions were measured by the universal goniometer, and the discrepancy between the two was recorded in degrees. After the universal goniometric evaluation followed by 3 min' rest, KFORCE Sens® evaluations were initiated.

2.3.2. KFORCE Sens®

Positioning was the same as for the previous evaluation. The device was attached by Velcro fasteners to the styloid of the ulna for flexion–extension and to the third carpometacarpal joint for deviation measurement. Evaluation was started by pressing the "start" button of the device, then followed the previous protocol. The device recorded the passive and active joint positions. The

Fig. 2. Evaluation of position sense with KFORCE Sens®. Extension (a), flexion (b), radial deviation (c) and ulnar deviation (d).

Table 1
Demographic data.

Demographic data		n	%
Gender	Male	14	26.4
	Female	39	73.6
Hand dominance	Right	45	84.9
	Left	8	15.1

	X ± SD	Med (range)
Age (years)	22.83 ± 1.28	22 (21–27)
Height (cm)	166.09 ± 7.37	165 (152–186)
Weight (kg)	62.19 ± 10.21	61 (41–92)
BMI (kg/m^2)	22.42 ± 2.38	22.66 (17.07–27.47)

X: mean; SD: standard deviation; Med: median.

Table 2
Evaluation of joint position sense with universal goniometer.

	Universal goniometer	X ± SD (0)	Med (range)
Dominant	Flexion/extension	6.14 ± 2.33	6.7 (2–11.4)
	Ulnar–radial deviation	3.85 ± 1.49	4.4 (1.2–5.9)
Non-dominant	Flexion/extension	6.2 ± 3.29	5.4 (1.9–13.1)
	Ulnar–radial deviation	4.08 ± 1.89	4.2 (0.9–10)

X: mean; SD: standard deviation; Med: median.

device has a gyroscopic inertial sensor allowing assessment, monitoring and rehabilitation of joint range of motion. It measures the angle with respect to the starting position of the limb in a specific anatomic plane. Evaluations with KFORCE Sens® were repeated 24 h later (Fig. 2).

2.4. Statistical analysis

The effect size obtained in the reference study [8] was quite strong (r = 0.958). As a lower effect size could be obtained (r = 0.4), power analysis showed a sample size of ≥34 people would ensure 80% power with a 95% confidence level.

Data were analyzed on SPSS 25.0 software (IBM Corp., Armonk, NY). Continuous variables were given as mean ± standard deviation and categorical variables as numbers and percentages. For scale validity and reliability analysis, reliability was assessed by test-retest intraclass correlation coefficient (ICC). The Spearman correlation coefficient was used as a reference in parallel form studies.

3. Results

Fifty-three volunteers (39 females, 14 males) with a mean age of 22.83 ± 1.28 years (range, 21–27 years) were included. Demographic data are shown in Table 1.

Mean position sense error in the dominant and non-dominant limbs was higher on universal goniometry (Table 2).

ICC shows a “Poor” correlation when <0.40, “Fair” between 0.40 and 0.59, "Good" between 0.60 and 0.74, and “Very Good” when >0.74 [12]. The test-retest joint position reliability on KFORCE Sens® was “Very Good” for all wrist movements (Table 3).

The relationships between position sense on KFORCE Sens® and the universal goniometer for all wrist movements are given in Table 4.

Spearman correlation coefficient “r” between 0.2 and 0.4 indicates weak correlation, between 0.4 and 0.6 moderate correlation, and between 0.6–0.8 very high correlation [13]. There was a very high correlation between flexion–extension movements on the dominant side (r = 0.955), and a high correlation between ulnar–radial deviation movements (r = 0.745). There was also a very high (r = 0.863) correlation between flexion–extension movements on the non-dominant side and a high correlation (r = 0.690) between ulnar–radial deviation movements ($p < 0.05$) (Table 4).

4. Discussion

In this study in which the KFORCE Sens® device was used to determine reliability of in the evaluation of wrist proprioception, the results showed that the device was reliable for evaluation. ICC

Table 3
Evaluation and test-retest joint position sense with KForce Sens®.

		Test		Retest		
	KForce Sens®	X ± SD (0)	Med (range)	X ± SD (0)	Med (range)	ICC (95% CI)
Dominant	Flexion/extension	5.81 ± 2.43	5.8 (1.7–10.2)	5.68 ± 2.29	5.7 (2.1–9.8)	0.964 (0.937–0.979)
	Ulnar–radial deviation	3.58 ± 1.42	3.3 (1–5.4)	3.48 ± 1.43	3.2 (1.1–5.3)	0.99 (0.982–0.994)
Non-dominant	Flexion/extension	5.69 ± 2.75	4.9 (1.9–11.2)	5.84 ± 2.58	5.5 (2–11.2)	0.982 (0.968–0.989)
	Ulnar–radial deviation	3.91 ± 1.75	3.6 (1.8–9.1)	3.77 ± 1.25	3.6 (1.8–7)	0.941 (0.898–0.966)

X: mean; SD: standard deviation; Med: median; CI: confidence interval; ICC: intraclass correlation coefficient.

Table 4
Correlation analysis of universal goniometer and KForce Sens® position sense measurements.

Position sense	KForce Sens®		Universal goniometer			
			Dominant		Non-dominant	
		r/p	Flexion–extension	Radio-ulnar deviation	Flexion–extension	Radio-ulnar deviation
Dominant	Flexion–extension	r	0.955	0.745	0.417	0.120
		p	0.001	0.001	0.002	0.392
	Ulnar–radial deviation	r	0.551	0.762	0.442	0.380
		p	0.001	0.001	0.001	0.005
Non-dominant	Flexion–extension	r	0.356	0.374	0.863	0.454
		p	0.009	0.006	0.001	0.001
	Ulnar–radial deviation	r	0.041	0.241	0.405	0.690
		p	0.768	0.082	0.003	0.001

r: correlation coefficient; p: Spearman correlation analysis.

for joint position sense was high (0.87−0.99) in all movements of the wrist, and greater than 0.93 in all movements except flexion/extension.

In a study of wrist rotation on electrogoniometry, ICCs for flexion/extension and ulnar–radial deviation movements were 0.94 and 0.96 respectively [14]. In a study aiming to standardize wrist position sense assessment for clinical purposes, in 55 healthy young people, ICC was weak to moderate (0.07−0.47) [11]. Tajali et al., in a study of the reliability of two different electrogoniometers in subjects with limited range of motion, reported that both devices had high reliability (ICC: 0.64−0.97), except only for radial deviation [15].

In a study of the reliability of the universal goniometer and the electrogoniometer in evaluation of wrist movements, ICCs were 0.81 (range, 0.62−0.91) for flexion, 0.87 (range, 0.78−0.94) for extension, 0.86 (range, 0.76−0.93) for radial deviation and 0.87 (range, 0.77−0.93) for ulnar deviation. Thus, reliability was moderate for all movements [12].

Khamwong et al., examining the reliability of wrist joint position sense using a Jamar goniometer in healthy adults, observed that the ICCs for position angle were significantly higher in flexion than in extension and all ICC values were lower than 0.75. In addition, joint position sense reliability was poor (ICC 0.11), especially at 45° flexion, where the data were discarded [16].

The universal goniometer is simple to use, non-invasive, and inexpensive [4]. Although manual goniometers are used everywhere, there are limited data regarding accuracy or reproducibility for wrist movement. In a study which examined the accuracy and reliability of wrist movements using three manual goniometric alignment techniques (ulnar, radial, and dorsal-volar) on cadavers, all three techniques showed similar degrees of accuracy and intra-rater reliability [17]. Based on this result, all ROM measurements were taken by selecting identical pivot points for both manual and KFORCE Sens® electrogoniometer positioning. In addition, to minimize the learning effect of test-retest comparison, all participants were allowed to try a preliminary test, but with no verbal clues given about their performance on it.

The present study, comparing the validity of the KFORCE Sens® device, used a universal goniometer, which is more reliable than an electronic goniometer [18]. Correlations with goniometry were in the moderate-to-high range for dominant and non-dominant flexion/extension and dominant ulnar–radial deviation position sense, whereas non-dominant ulnar–radial deviation correlated only moderately with non-dominant side goniometry.

Most electrogoniometry studies reported equipment reliability and inter-rater reliability [12,14]. Validity was generally evaluated as 'concurrent validity' and structural validity in terms of function and disability. A low-to-moderate correlation, between 0.32 and 0.63, was reported between two different electrogoniometry evaluations and patient-reported pain and functionality [15]. A strong correlation ($r = 0.65$; $r = 0.69$, $p < 0.001$) was found between smartphone and electrogoniometer results in ankle dorsiflexion and plantar flexion [19].

The advantages of the KFORCE Sens® device are that it is more practical for repeated evaluation, is more precise, can record evaluations, and is smaller than a universal goniometer. On the other hand, the software is only for smartphones and it does not come with any computer software, it has problems of connection with Android operating system devices, some limitations in the customizable evaluation feature and a lack of fixation in small joints to facilitate evaluation and size. However, a simple software update could solve all these problems, with software that can open special registration files for the individuals who are evaluated, create customizable evaluation programs for researchers, generate numerical and graphical data and output the evaluation results, Bluetooth® hardware that can be easily connected to all devices, and Velcro fastenings can easily be used in joints of all types and sizes. The device can be used more effectively and easily by clinicians and researchers. The extra cost, which is the biggest obstacle in choosing electrogoniometers rather than universal goniometers, will thus become justifiable.

5. Conclusion

The KFORCE Sens® device is a valid and reliable tool for evaluation of wrist position sense. It is a new approach that can be used in current practice, being fast, accurate and reliable. In the present sample, KFORCE Sens® had the advantage of providing normal values for joint position sense. Future studies should assess use of the KFORCE Sens® device for joint position sense and kinesthesia in different joints and disease groups, normal values should be obtained, and inter-tester validity should be assessed.

Ethics

Pamukkale University, Non-Invasive Clinical Research Ethics Committee, 22.12.2020, E-60116787-020-24.

Funding

The authors received no funding for this study.

Declaration of interest

The authors declare no conflicts of interest.

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