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The RELIABILITY OF A NEW DEVICE FOR ASSESSING ANKLE JOINT PRORIOCEPTION IN HEALTHY ADULTS

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The objective of this study is to evaluate the within-day and between-day reliability of a new device for assessing ankle joint prorioception. Eleven healthy adults, composed of seven males and four females, participated in the study. Each subject completed three sessions, two on the same day and the last one week later. In each session, three successful testing trials for ankle joint plantarflexion, dosiflexion, inversion, and eversion were performed. The mean values in one direction were calculated and analyzed. The within-day ICC values ranged from 0.808 to 0.973. The SEM for the device ranged from 0.118 ° to 0.448 °. The between-day ICC values ranged from 0.628 to 0.884. The SEM ranged from 0.287 °to 0.618 °. The measurements indicate good to excellent reliability of the device.

KEY WORDS: reliability, ankle joint, kinesthesia, proprioception

INSTRODUCTION: Proprioception is the afferent information that contributes to conscious sensations, total posture, and segmental posture. It is defined as the acquisition of stimuli by peripheral mechanoreceptors (such as joint motion, position, velocity, length, and tension of tissue) and the conversion of these mechanical stimuli into a neural signal that is transmitted along the afferent pathways to the central nervous system for processing (Lephart SM, 2000). Joint kinesthesia sense (JKS) and joint position sense (JPS) are two common measures of proprioception, which provide measures of conscious appreciation of joint motion and position sensibility. Joint kinesthesia is determined by establishing the threshold for detecting passive motion (Rozz et al., 2000) and using this threshold as criterion for detecting passive motion direction (Barrack et al., 1989). Custom-made devices are used to measure the knee (Pai et al. 1997; Xu, Hong, Li, and Chan, 2004; Li, Xu, and Hong, 2008) and ankle (Xu, Hong, Li, and Chan, 2004; Li, Xu, and Hong, 2008; Li, Xu, and Hoshizaki, 2012) joint kinesthesia. In these studies, the devices could only rotate along one plane and measure the kinesthesia of ankle joint in dorsiflexion and plantar flexion, and knee joint in flexion and extension. Little is known about the kinesthesia of ankle joint in inversion and eversion. A new version of the device for ankle joint kinesthesia, which was developed by the Shandong Toshimi Sports Industry Stock Co., Ltd., in Shandong province, China, was used in the study by Xu, et al. (2004) and Li, et al. (2008, 2012) to measure the ankle joint kinesthesia in saggital plane (dorsi/plantar flexion) and frontal plane (in/eversion). Their study sought to assess the reliability of this new device in measuring the kinesthesia of ankle joint in dorsi/plantar flexion and in/eversion rotations.

METHODS: A total of 11 healthy subjects (7 males, 4 females; age= 27.1±1.4 years, height = 171.2±5.5 cm, weight = 68.6±12.9 kg) were recruited to participate in the study. Subjects were free of previous musculoskeletal, cardiovascular, pulmonary, neurological, or systemic disease. An informed consent form was given to each subject prior to participation. This study was approved by the local medical ethics committee.

As illustrated in Fig 1, the device consists of a steel frame that is used to hang the lower extremity, two movable platforms (left and right) an operation panel, and several weights.

Figure 1. Instrumentation and measurement of ankle joint kinesthesia

The platform scan rotates around two perpendicular axes, driven by electronic motors. With the foot resting on the platform, the dorsiflexion, plantar flexion, extension, and inversion of the ankle joint can occur randomly from a starting position of 0 °. The angular velocity of each rotation is set to 0.4 °/s. During measurement, subjects should stop the ankle movements by pressing the red handheld switch once they sense the movements and the rotation direction. The angle displaced at this point is recorded to reflect the kinesthesia.

Each subject completed two sessions on separate days approximately one week apart. The two sessions were performed by the same experimenter, with a three-hour interval, at the same time of day, in the same laboratory environment. The experimenter underwent approximately three hours of training under an experienced operator to standardize the measuring procedures.

For data collection, each subject was seated on an adjustable chair and their bare dominant foot, described as the preferred leg for kicking a football (Gribble et al., 2007), was placed on the platform. The extremity could be adjusted so that the foot was in contact with the platform, the lateral axis of the device coincided with the plantar-dorsiflexion axis, and the longitudinal axis of the device coincided with the inversion-eversion axis of the ankle joint. The hip, knee, and ankle were positioned at 90 °. Only 50% of the weight of the lower extremity was loaded on the platform using the thigh cuff suspension system to control unwanted sensory cues resulting from the contact between the platform and the plantar surface of the foot. During measurement, the subjects wore a blindfold to remove any visual cues. Headphones with music playing were used to eliminate any auditory stimuli from the environment and the instrumentation. Each test movement started with the foot placed on the horizontal platform (position of 0 °). All subjects were required to concentrate on the testing foot, and to press the red handheld switch once they sensed foot movement and identified the direction. The experimenter recorded the angular displacement and direction of the movement. Before testing, the subjects were provided with three familiarization trials in each direction. The platform was randomly adjusted to rotate the foot into dorsiflexion, plantarfexion, inversion, or eversion at a random time interval of between 2 seconds to 10 seconds. The time between each trial was approximately 1 min. A total of at least 12 trials (three successful trials in each of the four directions) were performed in each session. The mean values in each direction were averaged for further analysis.

The data was analyzed using SPSS 16.0 for Windows. Significance was set at 0.05. Within-day and between-day reliability was determined using intraclass correlation coefficients (ICC) and associated 95% confidence intervals (CI). ICC (2×1) was used to calculate the reliability of measurement results, which implied a two-way random effects model where both people effects and measure effects were random. SEM was selected to test absolute reliability (Weir, 2005) and estimate the precision of measure (Deneger and Ball, 1993). A high SEM indicates a high level of error and implies non-reproducibility of tested values.

RESULTS: ICCs and SEMs of within-day and between-day were presented in Tables 1 and 2, respectively. The within-day ICC values ranged from 0.808 (dosiflexion) to 0.973 (plantarflexion). The SEM for the device ranged from 0.118 ° (plantarflexion) to 0.448 ° (eversion). The between-day ICC values ranged from 0.628 (dorsiflexion) to 0.884 (plantarflexion). The SEM ranged from 0.287 ° (plantarflexion) to 0.618 ° (inversion).

Table 1 Within-day reliability data for ankle joint prorioception

	ICC	95% CI		SEM
		lower bound	upper bound	
ankle plantarflexion	0.973	0.901	0.993	0.118 °
ankle dorsiflexion	0.808	0.288	0.948	0.354 °
ankle inversion	0.941	0.782	0.984	0.418 °
ankle eversion	0.854	0.457	0.961	0.448 °

ICC: intraclass correlation coefficient; SEM: standard error of measurement.

Table 2 Between-day reliability data for ankle joint prorioception

	ICC	95% CI		SEM
		lower bound	upper bound	
ankle plantarflexion	0.884	0.567	0.969	0.287 °
ankle dorsiflexion	0.628	-0.381	0.900	0.416 °
ankle inversion	0.864	0.494	0.963	0.618 °
ankle eversion	0.862	0.487	0.963	0.563 °

ICC: intraclass correlation coefficient; SEM: standard error of measurement.

DISCUSSION: ICC has become a popular choice for statistics in reliability studies. The most common methods of ICC are based on the calculation of the F-value from repeated measures ANOVA (Baumgarter, 1989). The evaluation criteria and accepted standards for ICC values are as follows: 0.00 to 0.39, poor; 0.40 to 0.59, fair; 0.60 to 0.74, good; and 0.75 to 1.00, excellent (Cicchetti and Sparrow, 1981).The SEM is a measure of absolute reliability and is expressed in actual units of measurement. The smaller the SEM, the greater the reliability (Bruton. et al., 2000).

Based on the ICC and SEM observed in this study, the new designed device indicated high reliability (0.808 to 0.973) except for ankle dorsiflexion (good, 0.628). This finding is consistent with that by Li et al. (2012) and Xu et al. (2004), who conducted a reliability test in 10 young and healthy people in two sessions held in consecutive days and one session held a week after the first measurement. The ICCs (0.68 to 0.92) showed moderate to high test-retest reliability.

The results showed that the new device has good reproduction and can offer reliable measurements for ankle joint proprioception. In this study, several factors led to good to high reliability. First, before data collection, three pre-test trials were provided to each subject for them to understand the testing procedure better and for errors in learning to be minimized. This familiarization could, in turn, enhance the reproducibility of the device. Second, all the measurements were performed in the same conditions, in terms of the testing protocol, body position, instructions, laboratory environment, and so on, which could contribute to reliability. As shown in Tables 1 and 2, within-day ICC in the present study were superior to between-day ICC, except for ankle eversion. Within-day SEMs were lower than between-day SEMs. These results indicate better within-day reliability, compared with between-day reliability, possibly due to the different time intervals. The within-day measurements were arranged to be 3 hours apart, whereas the between-day measurements were arranged to be 1 week apart. In general, such arrangements prevent both learning and fatigue effects on the reproducibility of the measures (SEKIR. et al., 2008). One limitation of this study is its small sample size, with only 11 participants, all of whom were healthy and between the ages of 24 years to 29 years. Further study should be conducted, employing a large age range (youth to elderly) and individuals with a history of joint pathology.

CONCLUSION: The results of this study indicate high within-day and between-day reliability coefficients of the new device for assessing ankle joint prorioception in healthy adults. The within-day reliability was higher than between-day reliability. The new device could be used to assess ankle joint prorioception in healthy adults. Further studies employing a larger sample size, large age range, and different joint pathologies are needed.

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