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Intra-Rater Reliability of Trunk Muscle Strength Measurement in the Lying Position by a Hand-Held Dynamometer

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Abstract

Introduction: *The purpose of this study was to validate the within-day and between-day intra-rater reliability measurements of belt-fixed trunk muscle strength measurements using a hand-held dynamometer (HHD) using intra-class correlation coefficients.*

Materials and Methods: *Forty healthy adult males without chronic low back pain were selected. Trunk muscle strength was measured using belt-fixed HHD in supine and prone positions on the bed. The average value and the relative trunk muscle strength were measured and verified for the within-day and between-day intra-rater reliability measurements.*

Results: *The ICCs of the absolute strength value were 0.87-0.97. The ICCs of the relative strength value in the between-day intra-rater reliability measurements ranged from 0.68 to 0.74. The high reliability of trunk muscle strength measurement with HHD using belt fixation in the lying position was obtained.*

Conclusions: *It was believed that HHD could be used as a low-cost and portable method for measuring trunk muscle strength in the clinical and research settings. However, the relative muscle strength measurement considering the effect of weight was slightly less reliable.*

Key words: *Reproducibility of Results; Abdominal muscles; Back muscles.*

Introduction

There is a strong relationship between muscle and quality of life[1)]. Sarcopenia, which is age-related decline in muscle mass, is of great interest to researchers. A number of studies have demonstrated that poor trunk muscle strength is associated with back pain, falls, and fractures of the spinal column[2)].

There are several devices for measuring trunk muscle strength, such as an isokinetic muscle strength evaluation device, an isometric muscle strength measurement device, etc. In addition, there is the Kraus-Weber test[3)], which is a method that requires a certain posture, and the Biering-Sorensen test[3,4)]. The method of measuring trunk muscle strength using a device is often challenging because of several problems such as requiring a place of installation and the high cost. The hand-held dynamometer (HHD) is a clinically applicable and quantitative evaluation method. It is often used clinically because it is easy to use, requires no installation space, and is relatively inexpensive.

One study that reported the relationship between HHD measurements and isokinetic muscle force measurement is the study by Statford and Balsor[5)]. Statford and Balsor reported a correlation between the measurement using HHD and isokinetic muscle strength measurement in the elbow flexor muscle[5]. Studies using HHD to measure trunk muscle strength include studies conducted with the participant in the sitting and lying positions. To verify the validity of trunk muscle strength measurements, trunk strength measurements using measuring instruments compared to HHD measurements are often performed in the sitting[6] or standing position[7]. A correlation between HHD measurement and other measuring instruments was observed when the study was conducted with the participant in the sitting or standing position[7]. However a study using HHD in the supine position showed low reliability[8]. A study by Ladeira et al.[9] measured muscle strength using an instrument for fixing HHD, and reported high reliability. In a study by De Blaiser C et al.[10], HHD was manually fixed and the muscle strength was measured with high reliability. In a systematic review, Stark et al.[11] reported that measurements using HHD at large joints, such as the knee joint, is relatively demanding. However, when measuring the isometric muscle strength of the knee joint or hip joint with HHD, high reliability has been reported using a method designed to help reduce resistance by fixing the belt[11-15]. From these, it can be concluded that few studies have confirmed the reliability of methods of trunk muscle strength measurement in a lying position using belt-fixed HHD.

Therefore, in order to confirm the reliability of the belt-fixed trunk muscle strength measurement in the lying position using HHD, this study aimed to verify the intra-class correlation coefficient for the within-day and between-day intra-rater reliability measurements.

Materials and Methods

The participants were 40 healthy adult males without chronic low back pain. Those with no pain from the lower back to the pelvis within the last 6 months and with no symptoms such as numbness in the lower limbs, as well as those who had not been diagnosed with lumbar spondylolysis, spondylolisthesis, or lumbar disc herniation were excluded from the study. The participants' age, height, and weight were 21.7 ± 0.5 years, 170.1 ± 5.2 cm, and 63.7 ± 8.2 kg, respectively. The purpose and content of the research and obtained data will not be used for anything other than the research itself. Moreover, Informed consent was obtained from all participants. This study was carried out with the approval of the Aino University Research Ethics Committee (Aino2019-09) and Kyoto Tachibana University Research Ethics Committee (19-13).

For the muscle strength measurement by HHD microFET2 (Hoggan Scientific, Salt Lake, UT, USA), HHD was used for both trunk flexion and extension strengths. The trunk flexion muscle strength was measured with the participant in a supine position on the bed with the lower limbs in flexed position, and the upper limbs stationed on the side. The anterior superior iliac spine of the pelvis was fixed with a belt. The HHD was fixed to the sternum with a belt, and the maximum isometric contraction strength was measured[8]. The trunk extension muscular strength was measured with the participant in a prone position on the bed with the lower limbs in the extended position (hip and knee joint 0°), and the upper limbs positioned on the side. The posterior superior iliac spine of the pelvis and thigh was fixed with a belt. The HHD was fixed to the 4th thoracic vertebra with a belt, and the maximum isometric contraction strength was measured[8]. For muscle strength measurement in HHD, after practicing several times, three measurements were taken, and the average value was used as the measured value. In addition, a relative strength value obtained by dividing the measured value by the body weight was obtained in order to calculate the relative muscle strength. These were used for reliability verification. Furthermore, the results of the within-day intra-rater reliability were measured twice within the same day and examined by the ICC. Additionally, in order to determine the between-day intra-rater reliability, the remeasurement results within 2 weeks were compared with the results of the initial measurement and examined by the ICC. ICC interpretation is based on Cicchetti and Sparrow[16]: 0.40 or less is low reliability, 0.40-0.59 is medium reliability, 0.60-0.75 is good reliability, and 0.75 or more indicates excellent reliability.

SPSS version 20 for Windows (IBM Co., Armonk, NY, USA) was used for the ICC statistical analysis. In addition, the measurement error was obtained using the 95% CI of the minimum detectable change (MDC95). MDC95 was determined by MDC95 = standard error of measurement (SEM) $\times 1.96 \times \sqrt{2}$[17].

Results

Table 1 shows the results of the within-day and between-day intra-rater reliability measurements of trunk muscle strength measurement using HHD. Table 2 shows the results of the within-day and between-day intra-rater reliability measurements of the results obtained by dividing the measured values of the trunk muscle strength by HHD by the body weight.

The measured values of the trunk flexion strength measured using HHD on the within-day intra-rater reliability measurements were 193.5-198.5 N, and the relative muscle strength values were 3.09-3.28 N/kg. The measured values of trunk extension strengths were 209.2-214.1 N and the relative strength values were 3.34-3.27 N/kg. The trunk flexion strengths of the between-day intrarater reliability measurements were 196.0-198.7 N, and the relative strength values were 3.14-3.27 N/kg. The trunk extension strengths were 211.7-204.2 N, and the relative strength values were 3.36-3.38 N/kg.

Regarding the ICC, the trunk flexion strength of the within-day intra-rater reliability measurements was 0.94, with a 95% CI of 0.90-0.97, and the relative strength value of 0.75, with a 95%CI of 0.56-0.86. The trunk extension strength was 0.97, with a 95% CI of 0.93-0.98, and the relative strength value was 0.82, with a 95% CI of 0.64-0.90. The trunk flexion strength of the between-day intra-rater reliability measurements was 0.93, with a 95% CI of 0.87-0.96, and the relative strength value was 0.74, with a 95% CI of 0.56-0.86. The trunk extension strength was 0.87, with a 95% CI of 0.88-0.98, and the relative strength value was 0.68, with a 95% CI of 0.47-0.82.

Table 1. *Within-day and between-day intra-rater reliability measurements of absolute strength value (N)*

			Mean±SD(N)	ICC	95%CI	SEM(N)	MDC_{95}(N)
Within	Flexion	1st	193.5±49.9	0.94	0.90-0.97	8.0	22.2
		2nd	198.5±56.3			9.0	25.0
	Extension	1st	209.2±62.7	0.97	0.93-0.98	10.0	27.8
		2nd	214.1±64.9			10.4	28.8
Between	Flexion	Day1	196.0±52.5	0.93	0.87-0.96	8.4	23.3
		Day2	198.7±55.1			8.8	24.5
	Extension	Day1	211.7±63.3	0.87	0.88-0.98	10.1	28.1
		Day2	204.2±50.2			8.0	22.2

Abbreviations: N, newton; SD, standard deviation; ICC, intra-class correlation coefficient; SEM, standard error of measurement; 95% CI, 95% confidence interval; MDC_{95}, 95% confidence interval of minimal detectable change

Table 2. *Within-day and between-day intra-rater reliability measurements of relative strength value (N/kg)*

			Mean±SD (N/kg)	ICC	95%CI	SEM (N/kg)	MDC_{95} (N/kg)
Within	Flexion	1st	3.09±0.83	0.75	0.56-0.86	0.13	0.35
		2nd	3.28±1.08			0.17	0.87
	Extension	1st	3.34±1.05	0.82	0.64-0.90	0.17	0.47
		2nd	3.51±1.14			0.18	0.51
Between	Flexion	Day1	3.14±0.88	0.74	0.56-0.86	0.14	0.39
		Day2	3.27±1.03			0.16	0.46
	Extension	Day1	3.38±1.05	0.68	0.47-0.82	0.17	0.46
		Day2	3.36±0.96			0.15	0.43

Abbreviations: N, newton; SD, standard deviation; ICC, intra-class correlation coefficient; SEM, standard error of measurement; 95% CI, 95% confidence interval; MDC_{95}, 95% confidence interval of minimal detectable change

Discussion

Regarding the reliability of trunk muscle strength measurement by HHD, the results were ICC 0.87-0.97, both in the within-day and between-day intra-rater measurements. However, in terms of the relative strength value divided by body weight, 0.75-0.82 was determined to be "excellent" in the within-day intra-rater reliability measurements; however, 0.68-0.74 was determined to be "good" in the between-day intra-rater reliability measurements.

In a study that showed reliability in measurements using HHD, Trudelle-Jackson et al.[18] confirmed the reliability by measuring the muscle strength of the hamstrings with HHD. The ICCs reported a high reliability of 0.87-0.98. McMahon et al.[19] confirmed the reliability by measuring shoulder abduction, wrist extension, hip extension, and ankle dorsiflexion with HHD. The intra-rater reliability reported that the ICC was 0.80-0.88. Stratford and Balsor[5] examined the validity and reliability of the flexion muscles of the elbow joint by measuring muscle strength through the range of motion and isometric muscle strength with HHD and isokinetic muscle strength devices. They reported that the ICC was 0.75-0.97, and reliability was confirmed. Moreover, it correlated with the result with the isokinetic muscle strength device. In our study, we measured the strength of the trunk muscle, several measurement results were different, and only similar results were obtained, and the usefulness of using HHD for measuring the strength of the trunk muscle was confirmed.

There are few studies that confirm the reliability by measuring trunk muscle strength using HHD. In a study by Jubany et al.[7], the measurement was performed in an upright position, and the ICC reported an excellent reliability of 0.9-1.0. In a study by De Blaiser et al.[10], HHD was manually fixed and measured with the subject in a lying position, and the ICC reported good to excellent reliability of 0.63-0.93. In our study, the measured ICC was 0.87-0.97, and similar excellent reliability was obtained. However, the ICC of the relative strength value was relatively low at 0.68-0.82. If this is a measurement in the sitting or standing position, it is considered that gravity influences the direction that assists the forces in the trunk flexion and extension directions. Therefore, in order to correct the physical disparity, the relative strength value is divided by the body weight. However, in the lying position, gravity does not help the forces in the flexion and extension directions. Therefore, to obtain the relative strength value, the method[7] that compensates for the effects of the moment arm, such as height and sitting height, is suitable. It was suggested that if the trunk muscle strength is measured in the lying position, it is not necessary to obtain the relative strength value for the purpose of making corrections using the body weight.

In this study, we were able to confirm the reliability of measuring trunk muscle strength by using HHD and fixing the belt in the lying position. It was believed that it could be used as a low-cost and portable method for measuring trunk muscle strength in the clinical and research settings.

As a limitation of this study, we could not confirm the difference due to gender because the participants were only male. In addition, it is not clear if they are equally reliable for female participants. Furthermore, it was necessary to confirm the inter-rater reliability measurements because only intra-rater reliability measurements were performed. It is believed that further verification will make it possible to use it for measurement in large-scale studies or as an evaluation tool for determining clinical efficacy.

Conclusions

In order to confirm the reliability of the belt-fixed trunk muscle strength measurement in the lying position using HHD, this study aimed to verify the intra-class correlation coefficient for the within-day and between-day intra-rater reliability measurements. We were able to confirm the reliability of measuring trunk muscle strength by using HHD and fixing the belt in the lying position. It was believed that HHD could be used as a low-cost and portable method for measuring trunk muscle strength in the clinical and research settings. However, the relative muscle strength measurement considering the effect of weight was slightly less reliable.

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