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Original Article

Effects of trunk stability on isometric knee extension muscle strength measurement while sitting

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Abstract. [Purpose] This study aimed to investigate the effect of trunk stability on isometric knee extension muscle strength measurement while sitting by performing simultaneous measurements with a handheld dynamometer (HHD) and an isokinetic dynamometer (IKD) in the same seated condition. [Subjects and Methods] The subjects were 30 healthy volunteers. Isometric knee extension muscle strength was simultaneously measured with a HHD and an IKD by using an IKD-specific chair. The measurement was performed twice. Measurement instrument variables and the number of measurements were examined by using the analysis of variance and correlation tests. [Results] The measurement instrument variables and the number of measurements were not significantly different. The correlation coefficients between the HHD and IKD measurements were ≥0.96. [Conclusion] Isometric knee extension muscle strength measurement using the HHD in the sitting position resulted in a lower value than that using the IKD, presumably because of the effect of trunk stability on the measurement. In the same seated posture with trunk stability, no significant difference in measurement values was observed between the HHD and IKD. The present findings suggest that trunk stability while seated during isometric knee extension muscle strength measurement influenced the HHD measurement.

Key words: Knee extension muscle strength, Handheld dynamometer, Isokinetic dynamometer

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INTRODUCTION

Isometric knee extension muscle strength is an important assessment tool that reflects mobility capability[1)]. The factors that influence the method of measurement should be well understood to accurately interpret the meaning of the measurement value. The measurement of isometric knee extension muscle strength is presumed to be affected by trunk stability, which consequently affects measurement values. The sensitivity of a handheld dynamometer (HHD) can be influenced by factors associated with knee extension muscle strength[2, 3)]. To obtain high reliability, a previous study utilized a belt to rigidly fix the sensor on the HHD[4–7)]. In general, an isokinetic dynamometer (IKD) is used to study the validity of knee extension muscle strength measurement. The correlation coefficients between the HHD and IKD have been reported to be 0.91[8)], 0.71[9)], and 0.86[10)]. Nevertheless, differences in the measurement methods have been shown to affect HHD measurement during the sitting position, with lower values than that obtained by IKD measurement[9, 10)]. The difference is postulated to be due to increased stability on sitting. Consequently, the present research group speculated that trunk stability while sitting could be tested as an independent influencing factor of the measurement of isometric knee muscle strength by using two instruments for the same seated posture. Therefore, knee extensor strength was simultaneously measured with a HHD and an IKD by using an appurtenant IKD chair with a strap and backrest to ensure stability on sitting.

This study contributes to the understanding of the measurement method where stability while sitting affects the measurement of knee extension strength by using a HHD.

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SUBJECTS AND METHODS

A total of 30 healthy volunteers (15 males and 15 females; age, 19–22 years; height, 165.7 ± 8.5 cm; body weight, 58.8 ± 9.1 kg) participated in this study. Knee extension muscle strength measurements were simultaneously obtained for the right lower extremity by using a HHD and an IKD. The examiner was a physical therapist. Muscle strength was measured by using a HHD (μTas F-1, Anima Corp., Tokyo, Japan) and an IKD (Biodex System 3, Biodex Medical System Corp., BIODEX, NY, USA). HHD measurements were obtained by replacing the pad of the lower leg cuff on the attachment with the exclusive use of the IKD and HHD sensors for knee extension measurements. The subjects were seated on an appurtenant IKD chair, with their trunk, pelvis, and thigh stabilized by using a strap. They were asked to sit upright, with their arms across their chest, throughout all the measurements. The HHD sensor was fastened to the foreside of the distal part of the lower leg by using a hook-and-loop fastener. The lower end of the sensor was fastened by using a hook-and-loop fastener to an area just above the malleolus. The sensor was placed on a thick rubber pad. The HHD was fixed by linking it to a support pillar on the lower leg cuff of the IKD attachment by using an anchor belt. The examiner was required to maintain the orientation of the sensor. Knee extensor strength was measured during isometric contractions at 90° knee flexion (Fig. 1). Maximum contractions were attained within 3 s and were maintained for 5 s. The maximum knee extensor strength values were recorded. All measurements were obtained after practice and prior orientation. In addition, all measurements were obtained on the same day, for two consecutive occasions on one side, at 30-s intervals. The torque value (Nm) of the HHD was calculated to align the units of measurement for both the IKD and HHD by measuring the distance from the lateral joint line of the knee to the height of the sensor midpoint.

Statistical processing was verified to ascertain the influence of the measurement instruments and the number of measurements by using two-way analysis of variance and Pearson's product moment correlation. Analysis was performed by using statistical software (R2.8.1). A probability (p) value of <0.01 was considered to be statistically significant.

The study protocol was approved by the ethics committee of Ryotokuji University (approval No. 2709) and was in accordance with the Declaration of Helsinki. Informed consent was obtained from each subject before participation.

RESULTS

The knee extension torque values are shown in Table 1. Factors related to the measurement instruments and the number of measurements revealed no main effects. The HHD and IKD measurements significantly correlated, with correlation coefficients of ≥0.96, which are shown in Table 2.

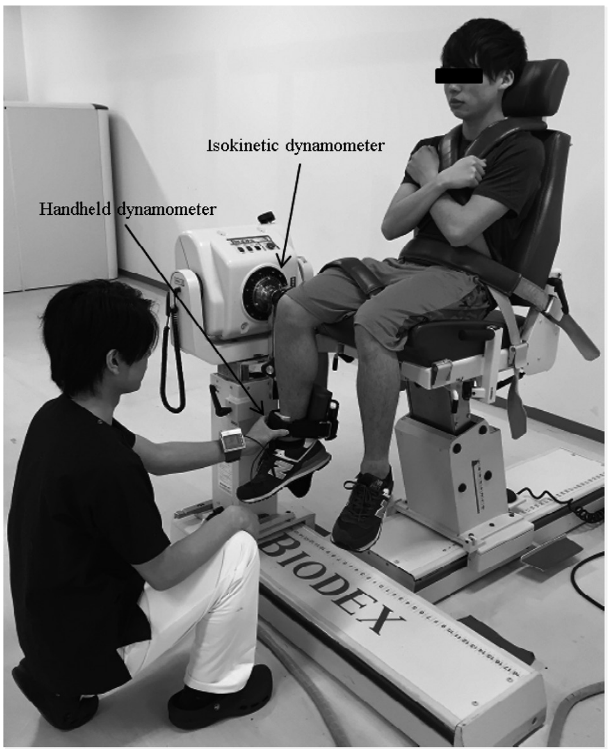

Fig. 1. Measurement method while sitting

Table 1. Knee extension muscle strength with HHD and IKD (n=30)

Instruments	First	Second
HHD	166.0 ± 51.3	167.9 ± 51.3
IKD	169.6 ± 52.3	169.9 ± 53.7

Data are presented as mean ± SD (Nm).
HHD: handheld dynamometer, IKD: isokinetic dynamometer

Table 2. Correlation analysis between the HHD and IKD (n=30)

Number of measurements	r	95%CI
First	0.968*	0.933–0.984
Second	0.989*	0.976–0.994

*p<0.01 by Pearson's product moment correlation analysis.
95% CI: 95% confidence interval

DISCUSSION

The results of the present study showed no significant differences between the measurement instruments or between the first and second measurement values for both the HHD and IKD. In addition, the relationship between the HHD and IKD showed high correlation. Therefore, the measurements were not affected owing to instrument precision.

The measurements in the sitting position, where high stability was attained by using the appurtenant IKD chair, showed no difference between the measured values obtained by using the HHD and IKD. The measurement of knee extensor strength using a HHD sometimes involves stabilizing and placing the upper limb at the side of the trunk to retain the posture of the subject. In addition, subjects may grab the bed end and sit upright with their arms across their chest during measurement. These measurement procedures are considered compatible depending on the subjects' characteristics. However, measurement in the sitting position without straps is presumed to be underestimated because of the muscle strength of hip extension and the trunk through compensatory movement. The present study found no significant difference between the measurement instruments. Thus, the stability of the sitting position was considered to affect knee extension muscle strength measurements using the HHD, whereby the HHD measurement values were lower than the IKD measurement values. According to the results of this study, the importance of sitting stability was established.

The measurable range of HHD is up to 980 N. In addition, one limitation of the present study is that the measurement condition was different from the actual clinical conditions. The trunk had to be stabilized by using a belt of the IKD chair, and the measurement using the HHD is not belt stabilized with the post of the IKD chair. In the knee extension muscle strength measurement using the HHD, this study examined the influencing factor of trunk stability and the measurement instrument precision. Further research is essential to examine the issue of the relationship of the stability of the trunk while sitting and belt-stabilized testing. Moreover, the effect of trunk on the knee extension muscle strength measurement while sitting should be investigated in subjects with high muscle strength, such as athletes.

REFERENCES

1) Katoh M, Kaneko Y: An investigation into reliability of knee extension muscle strength measurements, and into the relationship between muscle strength and means of independent mobility in the ward: examinations of patients who underwent femoral neck fracture surgery. J Phys Ther Sci, 2014, 26: 15–19. [Medline] [CrossRef]
2) Hyde SA, Goddard CM, Scott OM: The myometer: the development of a clinical tool. Physiotherapy, 1983, 69: 424–427. [Medline]
3) Wiles CM, Karni Y: The measurement of muscle strength in patients with peripheral neuromuscular disorders. J Neurol Neurosurg Psychiatry, 1983, 46: 1006–1013. [Medline] [CrossRef]
4) Katoh M, Yamasaki H: Comparison of reliability of isometric leg muscle strength measurements made using a hand-held dynamometer with and without a restraining belt. J Phys Ther Sci, 2009, 21: 37–42. [CrossRef]
5) Katoh M, Yamasaki H: Test-retest reliability of isometric leg muscle strength measurements made using a hand-held dynamometer restrained by a belt: comparisons during and between sessions. J Phys Ther Sci, 2009, 21: 239–243. [CrossRef]
6) Katoh M, Isozaki K, Sakanoue N, et al.: Reliability of isometric knee extension muscle strength measurement using a hand-held dynamometer with a belt: a study of test-retest reliability in healthy elderly subjects. J Phys Ther Sci, 2010, 22: 359–363. [CrossRef]
7) Katoh M, Isozaki K: Reliability of isometric knee extension muscle strength measurements of healthy elderly subjects made with a hand-held dynamometer and a belt. J Phys Ther Sci, 2014, 26: 1855–1859. [Medline] [CrossRef]
8) Martin HJ, Yule V, Syddall HE, et al.: Is hand-held dynamometry useful for the measurement of quadriceps strength in older people? A comparison with the gold standard Bodex dynamometry. Gerontology, 2006, 52: 154–159. [Medline] [CrossRef]
9) Katoh M, Hiiragi Y, Uchida M: Validity of isometric muscle strength measurements of the lower limbs using a hand-held dynamometer and belt: a comparison with an isokinetic dynamometer. J Phys Ther Sci, 2011, 23: 553–557. [CrossRef]
10) Bohannon RW, Bubela DJ, Wang YC, et al.: Adequacy of belt-stabilized testing of knee extension strength. J Strength Cond Res, 2011, 25: 1963–1967. [Medline] [CrossRef]