

# The intra- and inter-rater reliabilities of lower extremity muscle strength assessment of healthy adults using a hand held dynamometer

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**Abstract.** [Purpose] The purpose of this study was to examine the intra- and inter-rater reliabilities of lower extremity muscle strength assessment of healthy adults using hand held dynamometer. [Subjects and Methods] A total of 55 students (19 males and 36 females) in Y University in Gyeongsangnam-do, South Korea participated in this study. Lower extremity muscle strength was measured using a hand-held dynamometer (Commander Muscle Tester, JTech, USA). Flexion and extension strengths of the hip joint, the knee joint, and the ankle joint were measured. [Results] The intra-rater reliabilities were excellent (above 0.9) for the flexion and extension strengths of the ankle, knee, and hip joints. The inter-rater reliabilities were also excellent (above 0.8) for the flexion and extension strengths of the ankle, knee, and hip joint. [Conclusion] Lower extremity muscle strength assessment using a hand-held dynamometer provided consistent results when conducted by different examiners and when measured several times. Therefore, this method is a useful way of deriving objective and quantitative measurement values.

**Key words:** Muscle strength, Lower extremity, Reliability

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## INTRODUCTION

The body bears gravity using bones and muscles, and muscle force that works against gravity is needed to move the body and maintain posture. Particularly, lower extremity muscle strength is very important because it greatly affects postural stability and gait. Since gait ability determines functional independence of activities of daily living (ADL), lower extremity muscle strength affects quality of life<sup>1, 2)</sup>.

Many physical therapists clinically use the muscle manual test (MMT) to evaluate lower extremity muscle strength. MMT is simple and easy to use due to its short measurement time, but it is not very sensitive because it only has 5 grades, according to the gravity standard, and it has potentially large errors because the assessments are subjectively determined by therapists<sup>3-6)</sup>.

Treatment effects are usually evaluated by comparing outcome measures between before and after the intervention to assess whether or not a treatment or exercise prescription is being conducted properly. However, MMT is likely to create problems due to its subjective measurement and the high possibility of errors.

Using a dynamometer is one way of addressing these defects. A dynamometer measures pressure, so MMT using a dynamometer is a simple method of more objectively and quantitatively measuring muscle strength<sup>7)</sup>.

However, need to have high intra- and inter-rater reliabilities to be recognized as an objective tool. Therefore, this study analyzed the intra- and inter-reliabilities of MMT using a dynamometer for lower extremity muscle strength to investigate whether or not a dynamometer is an objective tool that can address the defects of MMT.

## SUBJECTS AND METHODS

This study was conducted with 55 students (19 males and 36 females) aged 19.8±1.2 years, who were 165.9±8.1 cm high, weighed 60.0±12.1 kg, and were attending Y University in Gyeongsangnam-do province. The selection criteria for the subjects were as follows: no disease that might have affected the test, and no visual impairment, hearing damage, nervous system or vestibular organ problems. Those who were unable to understand the nature of the experiment were excluded. Information about the study was provided to the subjects before their participation in accordance with the ethical principles of the Declaration of Helsinki, and all agreed to participate in the project by providing their written informed consent.

MMT was conducted using a hand-held dynamometer (Commander Muscle Tester, JTech, USA) to measure lower extremity muscle strength. Flexion and extension strengths of the hip joint, the knee joint, and the ankle joint were

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**Table 1.** Intra-rater reliabilities of MMT using a hand-held dynamometer

Muscle action (lbs)		Measurement		ICC (95% CI)
		1st	2nd	
Ankle	Dorsiflexion	20.13±7.48	19.47±6.84	0.974 (0.91–0.97)*
	Plantar flexion	23.20±9.71	23.15±9.76	0.966 (0.94–0.98)*
Knee	Flexion	23.13±11.62	22.27±12.64	0.986 (0.97–0.99)*
	Extension	33.34±16.10	33.49±15.88	0.989 (0.98–0.99)*
Hip	Flexion	35.60±13.67	34.34±14.73	0.974 (0.95–0.98)*
	Extension	33.57±11.40	33.35±11.97	0.941 (0.89–0.96)*

Mean±SD, \*p<0.05, ICC: intraclass correlation coefficient, CI: confidence interval

**Table 2.** Inter-rater reliabilities of MMT using a hand-held dynamometer

Muscle action (lbs)		Measurement		ICC (95% CI)
		Examiner 1	Examiner 2	
Ankle	Dorsiflexion	20.13±7.48	23.71±9.10	0.904 (0.84–0.94)*
	Plantar flexion	23.20±9.71	32.12±12.04	0.868 (0.77–0.92)*
Knee	Flexion	23.13±11.62	25.55±10.36	0.881 (0.79–0.93)*
	Extension	33.34±16.10	34.55±14.54	0.879 (0.79–0.92)*
Hip	Flexion	35.60±13.67	33.70±13.93	0.887 (0.80–0.93)*
	Extension	33.57±11.40	31.20±11.56	0.838 (0.72–0.90)*

Mean±SD, \*p<0.05, ICC: intraclass correlation coefficient, CI: confidence interval

measured.

For the measurements, subjects flexed their knees to 90 degrees in a supine position for the hip joint measurement, and in a sitting position for the knee joint measurement; and stretched their legs in a supine position for the ankle joint measurement to eliminate gravity effects and to move parallel to the ground<sup>3</sup>).

Two examiners measured the lower extremity muscle strengths of a subject to investigate the inter-rater reliability. Lower extremity muscle strengths of a subject were measured by a single examiner once a day for two days in a row to investigate the intra-rater reliability. The subjects were informed about the measurement procedure before the test. All the measurements are reported as the mean value ± standard deviation.

SPSS for Windows (version 20.0) was used to analyze the data. The intra-class correlation coefficient (ICC) was used to examine the intra- and inter-rater reliabilities. The statistical significance level used was  $\alpha = 0.05$ .

## RESULTS

The intra-rater reliabilities were excellent (above 0.9) for the flexion and extension strengths of the ankle, knee, and hip joints (p<0.05) (Table 1). The inter-rater reliabilities were also excellent (above 0.8) for the flexion and extension strengths of the ankle, knee, and hip joints (p<0.05) (Table 2).

## DISCUSSION

Lower extremity muscle strength is an important factor that greatly affects gait and determines an individual's level

of activities of daily living<sup>1, 2</sup>). Therefore, it is important to examine lower extremity muscle strength of not only patients, but also that of healthy people. Using a hand-held dynamometer is a simple, objective, and quantitative method of measuring lower extremity muscle strength<sup>3, 7</sup>). This study investigated the intra- and inter-rater reliabilities of measurements of the lower extremity muscle strength of young healthy adults with a hand-held dynamometer.

A single subject was measured once a day for two days in a row to analyze the intra-rater reliability. The reliabilities were excellent: ICCs above 0.9 for the hip joint, the knee joint, and the ankle joint. Particularly, the ICC of 0.989 for knee joint extension is in agreement with that of a previous study<sup>3</sup>). The standard deviations indicate high intra-rater reliabilities even though there were considerable differences in individual muscle strengths. These results show that the measurement outcomes were very consistent. A previous study of spinal cord injury (SCI) patients reported excellent reliabilities for muscle strength measurements with a hand-held dynamometer, but they were lower than those of this study<sup>8</sup>), probably because SCI patients show larger differences in individual physical level.

The inter-rater reliabilities were analyzed with one subject and two different examiners. They were lower than the intra-rater reliabilities, but still excellent (above 0.8) for the hip joint, the knee joint, and the ankle joint. Measurement of ankle dorsiflexion showed the highest reliability, which is in agreement with a previous study by Kelln et al<sup>9</sup>). Other previous studies have also reported very high reliabilities for the inter-rater reliability of hand-held dynamometer measurements<sup>10</sup>). The standard deviations indicate high inter-rater reliabilities even though there were considerable differences in individual measurement values.

When all the results were combined, the lower extremity muscle strength assessment using a hand-held dynamometer showed very consistent results when conducted with different examiners or examined several times. Therefore, this method is a useful way of obtaining objective and quantitative measurement values.

A limitation of this study was that the subjects were only young and healthy adults, therefore the results should be interpreted with care when applied to other age groups and populations. The reliabilities of hand-held dynamometer measurements of the muscle strength of other body parts besides the hip, knee, and ankle joint should also be investigated.

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