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Original Article

Examination of the intrarater reliability of ultrasound measurements of the thickness of the lumbar and lateral abdominal muscles in the prone position

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Abstract. [Purpose] This study aimed to examine the intrarater reliability when measuring the thickness of the lumbar and lateral abdominal muscles using ultrasound with the participants in the prone position. [Participants and Methods] The participants were 10 healthy adult males without chronic low back pain. The muscle thicknesses of the lumbar multifidus, erector spinae, obliquus externus abdominis, obliquus internus abdominis, and transversus abdominal muscles were measured using ultrasound with the participants in the prone position. [Results] The intraclass correlation coefficients of the within-day and between-day intrarater reliability measurements were 31.1–34.1 mm (lumbar multifidus), 32.0–33.5 mm (erector spinae), 7.4–8.0 mm (obliquus externus abdominis), 9.4–10.4 mm (obliquus internus abdominis), and 2.9–3.4 mm (transversus abdominal). The standard error of measurement and 95% confidence interval of minimal detectable change of the within- and between-day measurements were 0.1–1.2 mm and 0.3–3.4 mm, respectively, for each muscle. [Conclusion] The reliability of measuring the lumbar and lateral abdominal muscles in the prone position using ultrasound was confirmed. It was suggested that measurements during muscle activity and extremity movement are possible when participants are in the prone position.
Key words: Ultrasound measurement, Prone position, Lateral abdominal muscles

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INTRODUCTION

The lumbar and lateral abdominal muscles play an important role in spine stability and trunk control[1–3)]. Studies state that reduced contraction and thickness of the lumbar and lateral abdominal muscles can cause low back pain[1–4)]. Therefore, structural evaluation and functional evaluation of the lumbar and lateral abdominal muscles have attracted attention[2, 3)]. Ultrasound measurement is simple and non-invasive, and its utility in the field of rehabilitation, especially for structural and functional evaluation of the muscles is now known[2–5)]. Therefore, studies using ultrasound measurement are increasing. Several studies have compared ultrasound measurement and magnetic resonance imaging[2–4)]. Several studies have reported that multiple measurements are important for reliability[6, 7)]. Studies have also reported that the thickness of the lumbar and lateral abdominal muscles varies with postural changes[8–11)]. Some studies have reported in which the thickness of the lumbar multifidus (LM) and transversus abdominis (TrA) are measured with the pelvis in various positions[12, 13)].

However, the lumbar muscle thickness is often measured with the participant in the prone position[2, 4, 6)] and the lateral abdominal muscles are measured with the participant in the supine position[3, 6, 7)]. Measurement of the lumbar and lateral

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abdominal muscles in the same posture can help evaluate muscle activity and provide feed-back. This information is considered meaningful in the field of rehabilitation. To the best of our knowledge, few studies have measured the lateral abdominal muscle with the participant in the prone position. Measuring the lateral abdominal muscles in the prone position is considered to be affected by the ground in some way. However, it is important to consider the possibility of measuring in the same posture as the lumbar muscles, to confirm the reliability of measuring the lateral abdominal muscles in the prone position. Measurement of the lumbar and lateral abdominal muscles, which play a major role in spinal stability, in the prone position may also be useful in determining the degree of contribution. Therefore, this study aimed to examine the intrarater reliability for thickness measurement of the lumbar and lateral abdominal muscles using ultrasound with the participants in the prone position.

PARTICIPANTS AND METHODS

The participants in this study were 10 healthy adult males who did not have a history of chronic low back pain. The participants were aged 20.9 ± 0.3 years, height 169.2 ± 4.7 cm, body weight 57.0 ± 4.2 kg (mean ± SD). We explained to the participants that the purpose and contents of the research and the obtained data were not intended to be used except for research. The participants were assured of confidentiality, in writing and verbally, after which they provided informed consent. This research was conducted with the approval of the research ethics committee of University of Aino (2018-010).

We measured the thickness of the LM, erector spinae (ES), obliquus externus abdominis (OE), obliquus internus abdominis (OI), and TrA. For measuring muscle thickness, the Diagnostic Ultrasound System (Noblus, Hitachi, Ltd., Tokyo, Japan), was used with a linear probe L64 probe, B mode. The participants were placed in the prone position as close to the edge of the bed as possible. The upper limbs were placed on the body side, and the upper limb on the measuring side was placed on the same height as the bed so as not to interfere with the ultrasound measurement. The neck was turned to the measurement side to relax and no pillow was used. The measurements were recorded in units of 1 mm at the end of exhalation at rest. The average of two measurements was taken as the measurement value. The first and second average value were examined to determine the within-day intrarater reliability measurement. To investigate the between-day intrarater reliability, remeasurements were carried out in the same way within one week and the average values of the two measurements were obtained. The thickness of the LM was measured at a point 2 cm lateral to the fifth lumbar spinous process, the probe was placed perpendicular to the spine, the upper boundary line was subcutaneous tissue, and the lower boundary line was the vertebral level[2, 4, 6]. The thickness of the ES was measured at a point 5 cm lateral to the third lumbar spinous process; the probe was placed perpendicular to the spine, the upper boundary line was subcutaneous tissue and the lower boundary line was inside of the fascia[2, 4, 6]. The thicknesses of the OE, OI, and TrA were measured at the iliac crest along the anterior axillary line. The probe was placed perpendicular to the anterior axillary line. The distance from the inside to the inside of the fascia was measured[3, 6, 11]. The measurement site with was marked with an oil marker to enable repeat measurement. Light pressure was used with the probe so that each fascia could be clearly visualized on the screen. The researcher taking the measurements was a physical therapist accustomed to performing ultrasound, which enabled them to maintain constant pressure. Moreover, the researcher also underwent practice sessions before the actual measurements were performed. For statistical processing, SPSS version 20 for Windows (IBM Corporation, Armonk, NY, USA) was used and the ICC of the intrarater reliability of each muscle thickness measurement was examined. Measurement error was calculated using MDC_{95}. MDC_{95} was calculated with MDC_{95}=Standard Error of Measurement (SEM) $\times 1.96 \times \sqrt{2}$[14].

RESULTS

The ICC results of the within-day and between-day intrarater reliability measurement as well as the results of SEM and MDC_{95} are summarized in Table 1. In the within-day measurement, the mean values of the LM, ES, OE, OI, and TrA were 31.7 to 34.1 mm, 32.0 to 33.5 mm, 7.8 to 8.0 mm, 9.4 to 10.4 mm, and 3.0 to 3.4 mm, respectively. In the between-day measurement, the values of the LM, ES, OE, OI, and TrA were 31.1 to 32.6 mm, 32.0 to 33.3 mm, 7.4 to 8.0 mm, 9.5 to 10.4 mm, and 2.9 to 3.1 mm, respectively. The SEM of the within-day measurement and the between-day measurement was 0.1 to 1.2 mm for each muscle. The MDC_{95} was 0.3 to 3.4 mm for each muscle. The ICCs were 0.74 or more in all values, and the reliability of "normal" or more was recognized[15]. In the within-day measurement, ICCs showed values of 0.79 to 0.96 in each muscle and confirmed "normal" to "excellent" reliability. ICCs also showed values of 0.74 to 0.92 in each muscle the between-day measurement, and the reliability of "normal" to "excellent" was confirmed.

DISCUSSION

The purpose of this study was to investigate the intrarater reliability of the muscle thickness measurement of the lumbar muscle and lateral abdominal muscles using ultrasound with the participants in the prone position. We found that, the ICCs of the within-day measurement were in the range of 0.79 to 0.96, which were "normal" to "excellent". The in between-day measurement ICCs ranged from 0.74 to 0.92, which were "normal" to "excellent". Measurements in the prone position confirmed the reliability of "normal" to "excellent". However, in the within-day measurement and between-day measurement,

Table 1. Within-day and between-day intrarater reliability measurements

			Right					Left				
			Mean (mm)	ICC	95%CI	SEM (mm)	MDC95 (mm)	Mean (mm)	ICC	95%CI	SEM (mm)	MDC95 (mm)
Within	LM	1st	31.7 ± 3.6	0.91	0.69–0.98	1.2	3.2	34.1 ± 3.9	0.95	0.81–0.99	1.2	3.4
		2nd	32.1 ± 3.8			1.2	3.3	33.8 ± 3.8			1.2	3.3
	ES	1st	32.2 ± 3.6	0.88	0.61–0.97	1.2	3.2	33.5 ± 3.4	0.94	0.79–0.99	1.1	3.0
		2nd	32.0 ± 3.1			1.0	2.8	33.0 ± 2.9			0.9	2.6
	OE	1st	8.0 ± 1.7	0.95	0.81–0.99	0.5	1.5	7.9 ± 1.0	0.87	0.58–0.98	0.3	0.8
		2nd	8.0 ± 1.5			0.5	1.3	7.8 ± 0.8			0.3	0.7
	OI	1st	10.3 ± 1.8	0.89	0.64–0.97	0.6	1.6	9.4 ± 1.4	0.93	0.76–0.98	0.4	1.2
		2nd	10.4 ± 1.4			0.4	1.2	9.7 ± 1.3			0.4	1.1
	TrA	1st	3.4 ± 1.2	0.96	0.87–0.99	0.4	1.1	3.1 ± 0.6	0.79	0.40–0.94	0.2	0.6
		2nd	3.4 ± 1.1			0.4	1.0	3.0 ± 0.6			0.2	0.5
Between	LM	day1	31.9 ± 3.6	0.92	0.74–0.98	1.1	3.2	33.9 ± 3.8	0.86	0.56–0.96	1.2	3.3
		day2	31.1 ± 3.5			1.1	3.1	32.6 ± 3.2			1.0	2.8
	ES	day1	32.0 ± 3.3	0.86	0.55–0.96	1.0	2.9	33.2 ± 3.2	0.88	0.61–0.97	1.0	2.7
		day2	32.5 ± 3.1			1.0	2.7	33.3 ± 2.8			0.9	2.5
	OE	day1	8.0 ± 1.6	0.74	0.28–0.93	0.5	1.4	7.8 ± 0.8	0.75	0.29–0.93	0.3	0.7
		day2	7.4 ± 1.5			0.5	1.3	7.6 ± 0.9			0.3	0.8
	OI	day1	10.4 ± 1.6	0.83	0.47–0.95	0.5	1.4	9.5 ± 1.3	0.77	0.34–0.94	0.4	1.2
		day2	9.9 ± 1.6			0.5	1.4	10.0 ± 2.2			0.7	2.0
	TrA	day1	3.0 ± 0.5	0.77	0.35–0.94	0.1	0.4	3.1 ± 0.6	0.85	0.53–0.96	0.2	0.5
		day2	2.9 ± 0.4			0.1	0.3	3.1 ± 0.5			0.2	0.5

Data are the mean ± SD. LM: lumber multifidus; ES: erector spinae; OE: obliquus externus abdominis; OI: obliquus internus abdominis; TrA: transversus abdominal; ICC: intraclass correlation coeffcient; CI: confidence interval; SEM: standard error of measurement; MDC95: 95%CI of minimal detectable change.

the ICCs were 0.7, i.e., "normal", only in the measurement results of the lateral abdominal muscles; the OE, OI, and TrA. This suggests that caution is necessary for use in research and clinical situations.

Regarding the intrarater reliability, Tani states that the reliability is "excellent" when the ICC is 0.9 or more, "good" when it is 0.8 or more, and "normal" when it is 0.7 or more[15]. According to a previous study by Koppenhaver et al. on the intrarater reliability of the lumbar muscles measured using ultrasound, the thicknesses of the TrA and LM at rest and contraction were measured from the average values of two measurements. The ICCs of the within-day measurement were 0.96 to 0.99, and the ICCs of the between-day measurement were 0.87 to 0.98 as a result. This highlights the importance of multiple measurements[6]. Gnat et al. reported that the ICCs were 0.86 or higher for the intrarater reliability when measuring thickness of the TrA at rest[7]. In Park's study, the ICCs were 0.55 to 0.97, showing high reliability, when the lateral abdominal muscles were measured[16]. Chung et al. reported that the ICCs were 0.65 to 0.77 and high reliability was obtained when measuring the lateral abdominal muscles[17]. In the measurement results obtained with the participants in the prone position in our study, ICCs were obtained as the results of reliability of 0.74 to 0.96 for all measurements on the within-day and between-day measurement. In addition, MDC_{95} resulted in 0.5 to 3.4 mm as the within-day and 0.3 to 3.3 mm as the between-day measurement. In the study by Koppenhaver et al., the MDC of TrA and LM at rest were reported to be 0.4 to 2.8 mm as the within-day and 0.6 to 2.5 mm as the between-day measurement[6]. Our results were similar. MDC_{95} is used for studying the absolute reliability and shows the limit region that exists due to measurement error. If the measurement is not less than the value of MDC_{95}, it can be judged to be a true change occurring in the subject such as due to the intervention or age-related change[14]. From these facts, it was seen that reliable measurement can be performed if the operating method is accurate, including the probe use, measurement angle, and probe pressure; inaccuracies can cause errors in measurement. However, in the results of only the OE, OI, and TrA, which are lateral abdominal muscles, ICCs were 0.74 to 0.85, particularly the between-day measurement, which were "normal" to "good". It was thought that the abdomen was closer to the ground due to the prone position, and the lateral abdominal muscles were influenced by the contact surface. It is possible that the lateral abdominal muscles can be affected by a force that affects the shape of the muscle from the ground to some extent by taking the prone position. If measurement is performed in a bed with a different degree of softness, it can be considered to greatly affect the reliability. Therefore, it was confirmed that it is important to measure in the same situation as much as possible.

In this study, reliability was confirmed for the measurements of the lumbar and lateral abdominal muscles with the participant in the prone position using ultrasound. By measuring in the prone position, the need to change the posture and/or

the environmental setting was eliminated; moreover, the burden on the participant was reduced. It was also suggested that measurements during muscle activity and extremities movement during the prone position are possible. Moreover, if the difference in the functions of the lumbar and lateral abdominal muscles of patients with low back pain becomes clear compared with the healthy people, this knowledge could be used to develop the verification of rehabilitation effect.

The study had some limitation of this study. The number of participants was low. Moreover, we focused only on healthy adult males, and were unable to examine females, elderly participants, and participants with diseases such as low back pain. In addition, although this study examined the intrarater reliability, we thought it was also necessary to examine interrater reliability. Further studies will be required to explore these aspects.

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Conflict of interest

There are no conflicts of interest to declare.

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