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The Intra-Rater Reliability of Ultrasonography for the Measurement of Lumbar Multifidus and Erector Spinae Thickness in Different Positions in People with and without Active Extension-Related Non-Specific Low Back Pain

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Abstract

Background: The paraspinal muscles, including multifidus (MF) and erector spinae (ES) play key roles in the stability and movement of the lumbar spine. This study aimed to determine the intra-rater reliability of the ES and MF muscle thickness measures of the rehabilitative ultrasound imaging (RUSI) in people with active extension pattern (AEP) non-specific chronic low back pain and controls.

Methods: Fifteen females with AEP and 19 controls participated in this test-retest intra-rater reliability study, including two different testing sessions performed in four to seven days apart. The primary (raw) and derived (normalized) measures of the L4 MF and ES muscles\`thickness were examined in three different positions (prone, sitting, and standing) on both days. A two-way mixed average of intra-class correlation coefficient (ICC3, K) with confidence interval (CI = 95%) was used to determine the relative reliability. The standard error of measurement (SEM) and minimal detectable change (MDC) values at a CI of 95% were computed to examine the absolute reliability.

Results: The ICC values for the primary thickness of the L4 ES and MF muscles were from 0.85 to 0.91, except for MF muscle thickness in standing (ICC = 0.67) and sitting (ICC = 0.66) positions . The ICC values for derived data were lower in both groups. The SEM and MDC values were small enough to confirm the absolute reliability of the primary data.

Conclusion: This study supports the use of RUSI for examining the primary measures of the L4 MF and ES muscles in asymptomatic and AEP participants, but it should be used cautiously for assessing the derived measures.

Keywords: Low Back Pain, Multifidus, Paraspinal Muscles, Reliability, Ultrasonography

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Introduction

Low back pain (LBP) is one of the most prevalent musculoskeletal disorders (1-3) in industrialized and non-industrialized countries (4-7). It is a leading cause of disability and work absenteeism worldwide, and it is estimated

↑What is "already known" in this topic:
According to the literature, the RUSI could be used to evaluate the structure and function of the trunk musculature, especially deep muscles such as MF and ES muscles. The intra-rater reliability of RUSI for measuring the lumbar MF and ES muscle thickness has been investigated in both healthy and NSLBP people as a whole, but it is necessary to assess the reliability of the RUSI measures in different populations of people with LBP and in various positions before using it in research and clinical settings.

→What this article adds:
The results of the present study showed that the RUSI is a reliable method to evaluate the MF and ES muscle thickness measures in different positions in both AEP and control groups, but it should be used cautiously for assessing the derived measures.

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up to 80% of people suffer from LBP at some time during their lives (1, 2).

LBP is defined as chronic when pain maintains for more than three months (8). Nearly 85–90% of cases with chronic low back pain are categorized into the non-specific LBP (NSLBP) group. It is termed NSLBP when there is no specific pathology related to pain and disability (1, 9, 10). NSLBP is a multi-factorial and multidimensional disorder and includes a large heterogeneous population (1).

NSLBP can limit normal physical activity and decrease quality of life. In addition to the clinical manifestations, evidence suggests that LBP can disturb function and change the structure of paraspinal muscles. The lumbar paraspinal muscles, including multifidus (MF) and erector spinae (ES) muscles, play a critical role in spinal stability and mobility(11). Delay in the onset of activation(4) and fat infiltration(12-14) in the multifidus muscles have been found in chronic LBP people.

There are different methods for assessing muscle structure and function (4, 9, 15). Among these techniques, rehabilitative ultrasound imaging (RUSI) is a non-invasive and safe imaging technique (9) that is increasingly used in research and clinical practice (16) and provides valuable information. It has been proposed that before using a tool in research and clinical practice (16), the validity and reliability of its measurement methods should be established (17). The validity of RUSI for measuring muscle size has been demonstrated by comparing RUSI measures with magnetic resonance imaging (MRI) as the gold standard (15, 18, 19). Additionally, several studies have determined the reliability of the RUSI measures. The intra-rater reliability of RUSI for measuring of lumbar MF and ES muscle thickness at different vertebral levels has been investigated in asymptomatic (9, 11, 15, 16, 18, 20-29) and NSLBP (17, 25, 30-34) populations obtained on either the same day (9, 15, 17, 20, 22-24, 30, 34) or a different day (11, 16, 18, 21, 24, 26, 28, 29, 32-35).

The mentioned reliability investigations assessed the NSLBP people regardless of their related classifications. Various classification systems have been proposed to classify NSLBPs. In terms of classification systems, NSLBP people with common properties in a large group are ordered into small groups, or categories, with maximum between-group heterogeneity and within-group homogeneity (36). Based on O'Sullivan's classification system, NSLBP is divided into either movement impairments (MI) or motor control impairments (MCI). Despite movement impairments that lead to pain and reduction of normal movement in the direction of pain production, there is a maladaptive response in motor control impairments, and there is no movement impairment in the direction of pain production (1, 18).

The sub-groups of MCI include flexion pattern (FP), active extension pattern (AEP), passive extension pattern, lateral shifting pattern, and a multidirectional pattern (36). Previous electromyography studies have shown high levels of muscle co-contraction for superficial fibers of the lumbar multifidus in the AEP group during sitting (37) and standing (36). Based on the correlation between ultrasound measures with MRI (11, 18, 20) and electromyography (EMG) findings (38), it is assumed that RUSI could be used in the evaluation of deep back muscles in the AEP subgroup.

To the best of our knowledge, no study has investigated the reliability of deep paraspinal muscles in non-specific chronic LBP (NSCLBP) people with MCI.

This study aimed to determine the intra-rater reliability of ultrasound measures of the L4 MF and ES muscle thickness in different positions (prone, sitting, and standing) in people with and without AEP.

Methods

Participants

Fifteen NSCLBP females with AEP and 19 asymptomatic females as a control group participated in this test-retest intra-rater reliability study. All participants were conveniently recruited from students and staff of four university communities in Tehran, Iran. All testing procedures (the RUSI) were performed in the motor control lab of the Department of Physical Therapy of Tehran University of Medical Sciences (TUMS), Tehran, Iran.

Eligibility criteria for diagnosis of NSCLBP patients with AEP were: back pain for more than 3 months at the lower lumbar segments (L4-L5 and L5-S1), provocation of symptoms in active extension-related postures and movements, excessive lumbar lordosis at the symptomatic levels (1, 2, 37), having back pain scores between 2 and 7 according to the numeric pain rating scale (NPRS) (39), scores<41 on Tampa scale of kinesiophobia (TSK) questionnaire (40), and score >13% on Oswestry disability index (ODI) (41). Asymptomatic controls reported no history of back pain within the last year. The exclusion criteria for both AEP and control groups were as follows: specific LBP (e.g. disk herniation (3), previous lumbopelvic fracture or surgery (37), pregnancy, severe scoliosis, difficulty in lying prone, receiving back muscle training within the last 3 months (37). Participants with a high-risk level according to the STarT back questionnaire (score>4), were also excluded (42).

The study procedure was approved by the ethics committee of the Tehran University of Medical Sciences (TUMS) (Ethical code: 92/130/1915). Before participation in the study, all eligible participants signed the written informed consent form. Then, the demographic data of participants were recorded.

Sample size

This study was the first study that assessed the reliability of ultrasonography measures of the paraspinal muscles in NSCLBP people with MCI based on O'Sullivan's classification system, and it was considered an exploratory study. So, the priory sample size was not calculated for this study.

Instrument

An ultrasound imaging B-mode unit (Honda Electronics, HS 2600, Japan) with a 5 MHz convex head transducer and length of 70 mm was used to image the ES and MF muscles.

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Raters

For each participant, imaging was performed by two raters, a senior physical therapist (imager) and a colleague (recorder). The imager was a trained physical therapist on the O'Sullivan classification system who received specialized training in hands-on skills for muscle palpation and ultrasonography of the paraspinal muscles. The imager had 1.5 years of experience in the field of RUSI of the paraspinal and abdomen muscles.

Procedure

All ultrasound measures in this study were performed at the L4 level in three positions, including prone, sitting, and standing. Both the ES and MF muscles were assessed in the longitudinal view (parasagittal plan). The participants were examined in two sessions using the same protocol utilized in the first session with 4-7 days interval. All tests were almost repeated at the same time of the day.

In the AEP group, imaging was performed on the symptomatic side. If pain was reported bilaterally, the dominant side of the subject was considered the test side. The controls were matched with the AEP group for the test side. For each of the subjects, the sequence of imaging positions for each muscle was randomly selected. Before actual imaging, the study procedure was explained to the participants, and they were fully trained.

Positions

All the participants were assessed in three different positions (prone, sitting, and standing).

For the prone position (9, 16), subjects were positioned in the prone lying on the treatment table with their arms relaxed at their sides and feet hanging freely from the edge of the table. The forehead was relaxed on the table and the head was in the midline. To ensure the neutral position of the spine, a small roll was placed under the forehead and two rolls were placed under the shoulders to minimize the lumbar lordosis, one or two pillows were placed under the pelvis (9, 16, 43). Additionally, an inclinometer was used to make sure that the angle of the lumbosacral joint was less than 10 degrees (9, 43). In this study, the prone position was considered as the rest position.

For the sitting position, the participants were instructed to sit in a neutral position on a backless wooden chair, place their feet on the ground with shoulder-width apart, the arms relaxed at their sides, the forearms on the thighs, and keep the knees and hips at 90 degrees flexion (37). The participants looked at a fixed visual sign about 1.5 meters away from the chair at eye levels (44).

In standing, the participants stood barefoot, upright with their feet shoulder-width apart, and their arms at the sides (45, 46). The participants were asked to look forward (45) and hold the spine in a neutral position (46, 47).

Ultrasound imaging

All imaging was performed at the L4 level. The operator first palpated the spinous process of L4 and then marked it on the subject's skin with an eye linear pencil (9).

In this study, ES thickness was measured at the L4 level using an approach described by Watanabe et al. (20). The transducer was longitudinally positioned parallel to the spine at the L4 level at a distance from the spinous process of the L4. To ensure the correct position of the probe, it was slowly moved laterally from the midline until the transverse process could not be observed. Then the probe was moved slightly medially to be exactly on the most lateral part of the transverse process tip. The ES muscle thickness was measured at this location. The linear distance between the apex of the transverse process and the inner border of the posterior part of the thoracolumbar fascia was measured as ES thickness (20).

In this study, MF thickness was also measured at the L4 level in the parasagittal plane. As explained by Van et al. (48), for imaging MF muscle in the parasagittal section, the transducer was positioned longitudinally along the spine while its midpoint was located on the L4 spinous process. Then the transducer was moved very slowly lateral to the spinous process and angled a little medially until the L4-L5 zygapophyseal joint could be seen on the bottom of the screen. It was taken care not to slide the probe too laterally to maintain it in the plan of zygapophyseal joint. If the probe was moved too laterally, the images included the ES muscle and transverse process rather than the MF muscle and zygapophyseal joint. The L4 MF thickness was measured as the linear distance between the most posterior part of the L4-L5 zygapophyseal joint and the inside edge of hyperechoic fascia overlying the L4 MF muscle (48).

In all test positions, the raters approached from the left side of the participants, and the indicator mark on the probe was oriented cranially during the imaging process (49). Imaging for each muscle during every testing position was repeated three times and the mean value of three measurements was used for statistical analysis. The ultrasound images were saved and exported to the personal computer and analyzed offline using Image J software (National Institute of Mental Health of USA, version 1.51, https://imagej.net/) by the imager.

Variables

There were two types of variables in this study: 1) primary variables (raw variables) and 2) derived variables (normalized variables).

Primary variables included the measures of the ES and MF muscle thickness in the prone (rest position), sitting, and standing positions.

Derived variables included the thickness change and the percentage thickness change.

The thickness change was calculated as "contracted thickness - thickness at rest (prone position)".

The percentage thickness change was calculated as "100*(contracted thickness - thickness at rest (prone position)/thickness at rest (prone position)".

Statistics analysis

All analyses were performed using SPSS software (**S**tatistical **P**ackage for the **S**ocial **S**ciences, SPSS, Chicago, IL, version 20). The independent sample t-test was used to

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compare demographic data between the two groups.

Intra-rater reliability was assessed using relative and absolute reliability parameters. The relative intra-rater reliability of the RUSI measurements of the L4 MF and ES muscles was determined by using a two-way mixed average model of intra-class correlation coefficient (ICC_3, K) with a 95% confidence interval (CI). Relative reliability was determined by the intra-class correlation coefficient (ICC). ICC levels were interpreted as follows: ICC>0.75" excellent", 0.60<ICC< 0.74 "good", 0.40<ICC<0.60 "moderate" and ICC<0.40 " poor"(38). Standard error of measurement (SEM=SD ×√ [1-ICC]) and minimal detectable change (MDC=1.96 × SEM × √2) were calculated to assess absolute reliability (17). The significance level was set at 0.05.

Results

The demographic data of the two groups are shown in Table 1. All participants were females. No significant differences were found between the two groups in the baseline data. The ODI and TSK scores for the AEP group are also presented in Table 1.

The descriptive data for all measurements of the L4 ES and MF muscles are reported in Table 2 and Table 3 for each session, respectively.

The results of the intra-rater reliability for measurements of the ES and MF muscles are reported in Table 4 and Table 5, respectively.

ES measures

The ICC values for the thickness of the ES at the L4 for the control group in the prone and standing positions showed excellent reliability (ICC>0.85), while in the AEP group, the ICC values showed excellent reliability only for ES thickness in the sitting position (ICC=0.88). The ICC values of the ES thickness in both groups were at least 0.66 (Table 4).

For the ES thickness change and percentage thickness change, the ICC values were greater for the control group compared to the AEP group. The ICC values for the ES thickness change and percentage thickness change in the control group showed good to excellent reliability, while in the AEP group, the ICC values showed moderate to good reliability (Table 4).

The SEM and MDC values for the ES measures were greater in the AEP group compared to the control group. The SEM and MDC values in the control group ranged from 0.14 to 0.24 cm and from 0.38 to.60 cm, respectively (Table 4).

MF measures

The ICC values for the MF thickness in both groups in all testing positions showed excellent reliability (Table 5).

For the MF thickness change and percentage thickness

Table 1. Data at baseline for both groups (N=34) presented as mean (SD)

Variable	Control group n=19	AEP group n=15	*P* value
	Mean (SD)	Mean (SD)	
Age (year)	28.78 (5.43)	27.40 (3.58)	0.377
Weight (kg)	55.02 (6.65)	55.26 (5.52)	0.911
Height (cm)	161.88 (5.50)	163.13 (3.92)	0.469
BMI ($kg/m^{2)}$)	20.90 (2.46)	20.76 (1.90)	0.857
ODI	—	20.7 (7.08)	—
TSK	—	35.81 (6.82)	—

BMI=body mass index; AEP= active extension pattern; ODI= Oswestry disability index; TSK= Tampa scale of kinesiophobia

Table 2. Mean (SD) thickness of erector spinae muscle during standing, sitting, and prone positions

Position		Control group Mean (SD)		AEP group Mean (SD)	
		Measure	Remeasure	Measure	Remeasure
Standing	Thickness (cm)	3 (0.49)	2.96 (0.47)	3.15 (0.41)	2.97 (0.31)
	Thickness change (cm)*	0.27 (0.53)	0.36 (0.42)	0.37 (0.52)	0.42 (0.32)
	Percentage thickness change**	11.71 (20.07	15.08 (16.24)	15.77 (21.72)	18.15 (15.01)
Standing	Thickness (cm)	2.76 (0.39)	2.82 (0.38)	2.91 (0.35)	3.02 (0.41)
	Thickness change (cm)*	0.05 (0.35)	0.22 (0.40)	0.16 (0.35)	0.47 (0.44)
	Percentage thickness change**	3.36 (12.23)	10.21 (15.76)	7.28 (14.33)	20.39 (19.47)
Prone(rest)	Thickness (cm)	2.73 (0.46)	2.59 (0.40)	2.77 (0.44)	2.54 (0.44)

*= contract –rest **= 100× (contract -rest)/rest
AEP= Active Extension pattern

Table 3. Mean (SD) thickness of Lumbar multifidus (MF) muscle during standing, sitting, and prone positions

Position		Control group Mean (SD)		AEP group Mean (SD)	
		Measure	Remeasure	Measure	Remeasure
Standing	Thickness (cm)	2.56 (0.44)	2.59 (0.44)	2.64 (0.42)	2.55 (0.29)
	Thickness change (cm)*	0.25 (0.25)	0.33 (0.31)	0.74 (0.31)	0.60 (0.22)
	Percentage thickness change**	12.35 (12.77)	16.33 (16.19)	40.43 (16.87)	32.27 (14.72)
Sitting	Thickness (cm)	2.22 (0.42)	2.27 (0.38)	2.24 (0.54)	2.25 (0.42)
	Thickness change (cm)*	-0.07 (0.32)	0.02 (0.27)	0.33 (0.44)	0.29 (0.27)
	Percentage thickness change**	-2.41 (14.37)	2.01 (12.49)	18.36 (22.68)	15.61 (14.65)
Prone (rest)	Thickness (cm)	2.30 (0.44)	2.25 (0.40)	1.90 (0.34)	1.95 (0.29)

*= contract – rest **= 100 × (contract - rest)/rest

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Table 4. Intra-rater measurement reliability of erector spinae thickness measures

Position		Control group			AEP group		
		ICC 95%CI	SEM	MDC	ICC 95%CI	SEM	MDC
Standing	Thickness (cm)	0.85 (0.62-0.94)	0.18	0.49	0.67 (-0.05-0.90)	0.23	0.63
	Thickness change (cm)*	0.78 (0.43-0.91)	0.24	0.66	0.58 (-0.35-0.87)	0.33	0.91
	Percentage thickness change**	0.79 (0.47-0.92)	9.19	25.36	0.62 (-0.23-0.88)	13.38	36.92
Sitting	Thickness (cm)	0.66 (0.14-0.87)	0.22	0.60	0.88 (0.45-0.93)	0.12	0.33
	Thickness change (cm)*	0.78 (0.43-0.91)	0.16	0.44	0.53 (-0.53-0.85)	0.23	0.63
	Percentage thickness change**	0.80 (0.33-0.86)	5.46	15.06	0.60 (-0.29-0.88)	9.06	25
Prone (rest)	Thickness (cm)	0.90 (0.74-0.96)	0.14	0.38	0.66 (-0.08-0.89)	0.25	0.69

*= contract – rest **= 100× (contract - rest)/rest
ICC=intra-class correlation coefficient (95% confidence interval), SEM: standard error of measurement (cm); MDC: minimal detectable change

Table 5. Intra-rater measurement reliability of lumbar multifidus (MF) thickness measures

Position		Control group			AEP group		
		ICC 95%CI	SEM	MDC	ICC 95%CI	SEM	MDC
Standing	Thickness (cm)	0.87 (0.66-0.95)	0.15	0.41	0.89 (0.66-0.96)	0.13	0.35
	Thickness change (cm)*	0.52 (-.022-0.81)	0.17	0.46	0.55 (-0.45-0.86)	0.20	0.55
	Percentage thickness change**	0.53 (-0.21-0.82)	8.75	24.15	0.70 (0.04-0.91)	9.24	25.50
Sitting	Thickness (cm)	0.86 (0.65-0.94)	0.15	0.41	0.95 (0.84-0.98)	0.12	0.33
	Thickness change (cm)*	0.63 (-.04-0.85)	0.19	0.52	0.78 (0.29-0.93)	0.20	055
	Percentage thickness change**	0.53 (-0.19-0.82)	9.85	27.18	0.75 (0.18-0.92)	11.34	31.29
Prone (rest)	Thickness (cm)	0.91 (0.76-0.96)	0.13	0.35	0.90 (0.69-0.97)	0.10	0.27

*= contract – rest **= 100× (contract - rest)/rest
ICC=intra-class correlation coefficient (95% confidence interval), SEM: standard error of measurement (cm); MDC: minimal detectable change

change, the ICC values were greater in the AEP group than in the control group. The ICC values of the MF thickness change and percentage thickness change in the control group were between 0.52 and 0.63, and in the AEP group were between 0.55 and 0.75 (Table 5).

The SEM and MDC values for all measures of the MF thickness in all positions were lower in the AEP group compared to the control group. The SEM and MDC values for the MF muscle thickness in the control group varied from 0.13 to 0.15 cm and from 0.35 to 0.45 cm, respectively (Table 5).

Discussion

It is the first study that evaluated the intra-rater reliability of ultrasonography measures of the ES and MF muscles in NSCLBP people with AEP and controls in the prone, sitting, and standing positions. The intra-rater reliability is defined as the reproducibility of measurements under the same conditions by one rater in two different sessions.

The results of the study indicate good to excellent relative reliability for the ES thickness and excellent reliability for the MF muscle thickness in all testing positions.

For the MF percentage thickness change, the ICC values were greater in the AEP group compared to the control group, while the control group had higher ICC values for the ES percentage thickness change than the AEP group.

Koppenhover et al. showed that using the average values of three repeated measures of muscle thickness decreases SEM values up to 50% and increases the reliability (17); therefore in this study, both the ES and MF muscles were imaged three times in each testing position and the mean values of three measures were used for statistical analysis.

Primary (raw) measures

The intra-rater reliability of the ES thickness based on the ICC was excellent for the controls in the prone and standing positions and for the AEP group in the sitting position (ICC≥0.75). Several studies examined the reliability of the ES muscles using ultrasonography. Most previous studies included asymptomatic subjects without back pain (18, 20).

Watanaba et al. evaluated the reliability of the ES thickness at all lumbar levels in three different trunk postures. They reported excellent reliability for the ES thickness in the neutral sitting position (ICC=0.95). In our study, the ICC value of the ES muscle thickness of the AEP group in the sitting position was 0.88, while the control group showed an ICC value of 0.6 (moderate reliability) for the ES thickness, which was lower than Watanaba's study. A possible explanation for this result in our study might be due to the difference in the neutral sitting position of the participants, the uncomfortable position of the imager (50), and the different pressure levels exerted on the probe by the imager between the two sessions that could have resulted in different muscle thickness measures for the control group in the sitting position.

An example of the reliability of the ES muscle thickness in the prone population is the study of Belavely et al., which reported excellent intra-rater reliability (ICC=0.81) for the ES thickness in asymptomatic males (18). In line with Belavely's study, excellent reliability based on the ICC was also observed for the controls of the present study in the prone position.

To the best of our knowledge, no study evaluated the reliability of the ES muscle thickness measures in the standing position. In this position, it was difficult to keep the ultrasound probe steady during the imaging so the lower reliability of the ES measures may be related to the sliding of the probe on the skin and also difficulty in repositioning it on the body between successive measurements. Perhaps it is better to use a probe-supporting system that holds the probe in its location during imaging in the standing position (26, 30).

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Our results showed excellent intra-rater reliability for the MF muscle thickness in all testing positions for both groups. Our findings in the prone position were in accordance with those of the previous reliability studies that examined the reliability of the MF muscle thickness at the L4-L5 level in controls (17, 24, 26-29, 32, 48, 50-52) and LBP (30, 31, 52) people. Based on their results, the ICC values ranged from 0.88 to 0.99 for asymptomatic subjects and from 0.84 to 0.94 for people with LBP.

Additionally, some studies evaluated the reliability of the MF muscle thickness at the level of L4-L5 in the sitting and standing positions (17, 26, 48) .Magnum et al. determined the intra-rater reliability for the activation ratio (AR) of the MF muscle at the level of L4-L5 in prone, sitting, and standing positions. They reported that the AR of the MF muscle is reliable only in the prone position (ICC=0/28) (26) . Our findings were not comparable with their results because, in our study, the AR was not determined.

Based on our findings, the ICC values of most primary measures of the MF muscle thickness were lower in the AEP group compared to the control group, except for the MF muscle thickness in the standing position. These results were in line with the finding obtained by Liu et al. (31). There are several possible explanations for these results. The observed results could be attributed to changes in muscle consistency or fatty infiltration (13, 53, 54), fibrous changes, muscle disuse, and inflammation (55). These changes may result in increased echogenicity and unclear muscle boundaries. Furthermore, the disturbed motor control or faulty motor performance and muscle deconditioning might have caused difficulties in adopting repeatable neutral sitting and standing positions (50).

The absolute reliability parameters, including SEM and MDC for primary variables, were in a small range. The SEM and MDC values for the measures of ES muscle thickness were greater in the AEP group compared to the control group. The SEM and MDC values for all measures of the MF muscle thickness in all positions were lower in the AEP group compared to the control group.

Derived (normalized) measures

The ICC values for the ES thickness change and percentage thickness change in the control group showed good to excellent reliability, while in the AEP group, the ICC values showed moderate to good reliability. The ICC values of the MF thickness change and percentage thickness change in the control group were in the moderate range, and in the AEP group were between good to moderate. Generally, the ICC values for the derived measures (changes in the muscle thickness and percentage changes of the muscle thickness) were smaller than ICCs for primary measures. These results also accord with earlier observations (17, 24, 28, 29).

The lower ICC values for derived variables as described by previous authors (24, 28, 29) may be due to combining the errors related to the measurements during the rest (prone position) and contraction (neutral sitting or standing position). An increase in measurement errors can result in greater SEM and MDC values.

Limitations

Our study had several limitations. One limitation was that we only evaluated the females. Another limitation was that just one subgroup of the NSLBP people was included in this study, while it is probable to find different results in other populations of NSLBP people with either MI or MCI, so further study is required to determine the reliability of the ultrasonography measures in other populations. Therefore, it is suggested to investigate the reliability of ultrasonography measures of the paraspinal muscles in more functional positions in a larger sample size including both males and females. It is also proposed to examine the reliability of RUSI measures in people with different activity levels who are classified into different subgroups of NSLBP.

Conclusion

In conclusion, this study supports the use of RUSI as a reliable method for assessing the thickness measures of the MF and ES muscles in both AEP and control groups in the research and clinical settings. Also in line with previous research the reliability of the derived measures was poor to moderate indicating that it should be used and interpreted cautiously for the derived data.

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Conflict of Interests

The authors declare that they have no competing interests.

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