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Lumbar Multifidus Muscle Characteristics, Body Composition, and Injury in University Rugby Players

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Context: A smaller lumbar multifidus (LM) muscle was reported to be a strong predictor of lower limb injury in professional Australian Football League players. However, despite the high prevalence of low back pain (LBP) and lower limb injury in rugby players, their LM characteristics have yet to be explored.

Objective: To (1) examine LM characteristics in male and female university rugby players and their possible associations with LBP and lower limb injury and (2) investigate the relationship between LM characteristics and body composition in this group of athletes.

Design: Cross-sectional study.

Setting: University research center.

Patients or Other Participants: Thirty-four university rugby players (20 women, 14 men).

Main Outcome Measure(s): Ultrasound measurements of LM cross-sectional area (CSA), thickness, and percentage change in thickness during contraction were obtained bilaterally, at the L5-S1 level, in prone and standing positions. Body composition measures were obtained using dual-energy x-ray absorptiometry. Self-reported questionnaires were used to obtain LBP and lower limb injury history.

Results: Players who reported LBP in the previous 3 months showed a smaller percentage change in thickness during contraction in the standing position ($F = 5.21$, $P = .03$). The LM CSA side-to-side asymmetry (right versus left) was greater in players who reported having a lower limb injury in the previous 12 months ($F = 4.98$, $P = .03$). The LM CSA was significantly associated with body composition measurements. A greater percentage change in thickness during contraction was significantly associated with a lower percentage of body fat. The LM echo intensity was strongly associated with the total percentage of body fat and was significantly greater in women.

Conclusions: The influence of body composition on LM morphology in athletes cannot be ignored and warrants further investigation. Our findings also provide preliminary evidence of an association among LM morphology, LBP, and lower limb injury in university rugby players.

Key Words: paraspinal muscles, low back pain, ultrasound, lower limb injury, dual-energy x-ray absorptiometry

Key Points

- Players with a history of low back pain showed decreased contractile ability of the lumbar multifidus (LM) muscle in the standing position.
- Greater LM cross-sectional area asymmetry in the prone position was associated with lower limb injury.
- Characteristics of the LM were strongly correlated with body composition measurements.

Elite rugby athletes are prone to various forms of physical stress originating from high-intensity collisions during sport-specific training and year-round physical preparation that cause high physical loads on the spine, pelvic region, and upper and lower extremities.[1] Such high physical stresses may affect the development of acute and chronic spine conditions. Low back pain (LBP) is more common among athletes in contact and combat sports and is often associated with sport-specific mechanical loads and movement patterns.[2] Although the incidence of LBP is higher among athletes taking part in high load-intensity sports, few researchers have specifically examined the prevalence of LBP in rugby players. Whereas 40% of high school rugby players with no radiographic abnormalities reported LBP at the end of a single season,[2] 39% of former professional players (9 of 23) had chronic LBP.[3] Low back pain was also very common in elite Australian Football League (AFL) players.[4]

It is well recognized that LBP leads to motor-control impairments and altered body kinematics, which can present as a wide array of dysfunctions, including hypomobility or hypermobility of the involved lumbar segments, changes in paraspinal muscle recruitment and coordination, and movement fear or avoidance.[5] Paraspinal muscle morphologic changes (eg, atrophy,[6–8] asymmetry,[6,9] fatty infiltration),[10,11] especially of the lumbar multifidus (LM) muscle, and functional deficits[12] (eg, altered muscle activity) have also been reported in patients with LBP. The LM muscle plays a critical role in providing spinal stability during trunk movement and spine proprioception,[2] which likely become impaired when atrophy, fatty infiltration, or both are present. Such degenerative changes were described in athletic and nonathletic populations with LBP. More specifically, localized LM muscle atrophy and side-to-side asymmetry were observed in elite cricketers[8] and off-road cyclists with LBP.[13] Lumbar multifidus muscle atrophy, functional deficits, or both have also been identified in elite ballet dancers,[14] ice hockey players,[15] and gymnasts with sway-back posture.[2] A smaller LM cross-sectional area (CSA) and greater side-to-side asymmetry were strong predictors of lower limb injuries in elite AFL players.[9] Proper function of the trunk muscles is critical for maintaining the integrity of the kinetic chain and distributing forces to the lower limbs. However, we are not aware of any investigators who have assessed LM muscle morphology, function, or both in elite rugby players, despite the high incidence of LBP and lower limb injury in this population. Previous evidence of structural and functional changes highlighted the importance of assessing LM muscle morphology and neuromuscular control in elite athletes, which may have important implications for susceptibility to injury.

Although the authors of most imaging studies have assessed the LM in prone position, nonathletic populations have shown increased LM CSA from prone lying to upright standing.[16,17] Such findings suggest that the assessment of LM may be more accurate in a standing or functional position, when the LM is contracted in a stabilizing role.[17] Indeed, the percentage change in LM thickness change in the standing position (eg, LM thickness while standing compared with LM thickness while standing and performing a contralateral arm lift) is also expected to be much smaller than in the prone position.[15] Yet LM muscle characteristics and function in such positions have been assessed in few ultrasound-imaging studies,[15–17] and it remains unclear whether LM morphology and function assessed in a more functional position, such as standing, differ between players with and those without LBP, lower limb injury, or both. Furthermore, even though it is well established that paraspinal muscle morphology and composition (eg, fatty infiltration) are confounded by factors such as age, sex, physical activity level, and body composition,[11] the variable used most frequently to adjust for intersubject variability in anthropometric and body composition differences is body mass index. However, this measure is a poor indicator of body composition, especially in athletic populations, as it does not differentiate between lean and fat mass.[18] Accordingly, in a study of elite ice hockey players,[15] researchers demonstrated that body composition measurements obtained from dual-energy x-ray absorptiometry (DEXA) were strongly correlated with LM muscle size (eg, CSA) and echo intensity (EI; eg, indicator of fatty infiltration and connective tissue using the ultrasound brightness scale) as opposed to BMI. Such findings suggest that the influence of body composition measurements on LM muscle morphology and function is an area for further examination, especially in athletes.

Therefore, the purpose of our study was to (1) examine LM muscle morphology and function (eg, in prone and standing positions) in male and female university rugby players, (2) compare LM muscle morphology and function (in prone and standing positions) in players with and those without LBP and with a history of lower limb injury, and (3) investigate the relationship among LM muscle morphology, function, and body composition in these athletes. We hypothesized that players with LBP would have a smaller LM muscle, greater CSA side-to-side asymmetry, and higher risk of lower limb injuries. We also hypothesized that greater lean muscle mass and a greater percentage of body fat would be associated with LM CSA and EI, respectively.

METHODS

Participants

A total of 37 rugby players (21 women, 16 men) from Concordia University varsity teams volunteered to participate in this study. Three players were excluded (1 woman, 2 men) due to missing data and poor quality of ultrasound images, for a final sample of 34 players (20 women, 14 men). All available players were invited to participate in this study and, thus, we did not consider players' positions (eg, forward, back) in order to maximize the sample size. Exclusion criteria were a history of severe spinal trauma or fracture, spinal surgery, spinal abnormality (eg, scoliosis $>10°$), or pregnancy. The study was approved by the Central Ethics Committee of Health and Social Services from the Ministry of Quebec. Players provided informed consent before the assessment.

Procedures

All players were tested during the preseason (1 session of approximately 30 minutes) and completed a self-administered questionnaire regarding demographic information and history of injury. Athletes were asked whether they had LBP (eg, pain between T12 and the gluteal fold) during the previous 3 months (*yes* or *no*), and completed a visual numeric pain scale (0–10 scale; 0 = *no pain*, 10 = *worst imaginable pain*) if they reported the presence of LBP. Players with LBP were also asked to report the pain location (eg, *centered*, *right side*, *left side*) and pain duration (in months). Similarly, they were also asked about any lower limb injury in the previous 12 months and to specify the injured body part.

Ultrasound Imaging

The LM assessments were performed using a LOGIQ e ultrasound machine (GE Heathcare, Milwaukee, WI) with a 5-MHz curvilinear transducer. All imaging specifications (frequency = 5 MHz, gain = 60, depth = 8.0 cm) remained consistent for all images. The reliability and validity of using ultrasound to assess LM muscle size and thickness have been established.[19,20]

Prone Lying Measurements. Players were first placed in a prone position (on a therapy table) to assess LM CSA. A pillow was placed under the abdomen to relax the paraspinal musculature and minimize lumbar lordosis. Before imaging, the spinous process of L5 was palpated and marked with a pen. The ultrasound transducer was then placed longitudinally along the midline to confirm the location of the L5 level. Once the location was confirmed, the transducer was rotated transversally over the L5 spinous process. The LM muscle was then imaged bilaterally; separate images were obtained on the right and left in players with larger muscles. Three images were saved for

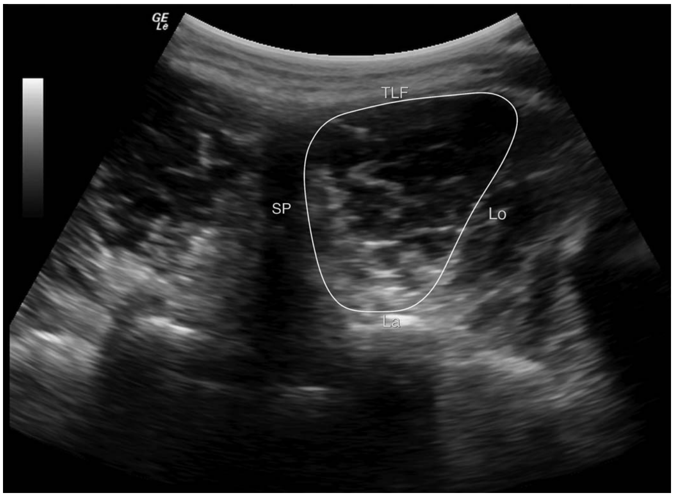

Figure 1. Lumbar multifidus (LM) cross-sectional area measurement in a male rugby player at the L5 vertebral level. Spinous process (SP) in the center of the image, echogenic laminae (La), longissimus (Lo), and thoracolumbar facia (TLF) were used as landmarks to define the LM muscle borders.

each side. We chose this level because prior evidence[9] suggested that a smaller LM CSA and increased side-to-side asymmetry at L5 are strong predictors of LBP and lower limb injury in professional AFL players.

Lumbar multifidus thickness measurements at rest and during submaximal contraction (eg, function) were then acquired in the same position. Images were obtained bilaterally, in the parasagittal view, to allow for visualization of the L5-S1 zygapophyseal joints. Players were first told to relax while 3 images were acquired bilaterally at rest. Then, they were instructed to perform a contralateral arm lift (eg, lift the arm 5 cm off the table with the shoulder at 120° of abduction and elbow at 90° of flexion) while holding a handle weight to induce a submaximal contraction (eg, approximately 30% of maximum voluntary contraction).[20] The handheld weight was based on the individual's body weight[20]: (1) <68.2 kg = 0.68-kg weight, (2) 68.2 to 90.9 kg = 0.9-kg weight, (3) >90.9 kg = 1.36-kg weight. Participants were asked to maintain the contraction for 3 seconds and to hold their breath at the end of normal exhalation to minimize the effect of respiration on the LM measurement. Each person performed a practice trial followed by 3 contralateral arm lifts on each side.

Standing Measurements. For the standing measurements, players stood barefoot on the floor with their arms relaxed on each side. To achieve a habitual standing posture, participants marched on a spot for a few seconds and remained on the position where their feet landed. The same procedure described earlier was used to obtain the LM measurements at rest in this position. Then, LM muscle contraction was achieved via contralateral arm lifts (shoulder in 90° of flexion, elbow in full extension, wrist in neutral position with palm facing down)[15,17] while holding the weight that was previously determined. Again, contractions were maintained for 3 seconds, and each player had a practice trial followed by 3 arm lifts on each side.

Imaging Analysis. Ultrasound images were analyzed offline using OsiriX Lite imaging software (version 9.0; Pixmeo, Geneva, Switzerland). We obtained the LM CSA measurements by tracing the muscle borders on both sides (refer to Figure 1 for specific anatomical landmarks). The relative percentage of CSA asymmetry between the right and left sides was calculated using the following formula: [(Larger side − Smaller side)/Larger side × 100]. For LM muscle thickness, the tip of the L5–S1 zygapophyseal joint to the inside edge of the superior muscle border was measured, both at rest and during contraction (Figure 2), in prone and standing positions. The average of 3 measurements (on 3 different images) for each side was used in the analyses. The percentage change in thickness was used to assess LM function and contractile ability (in prone and standing positions) using the following formula: [(Thick-

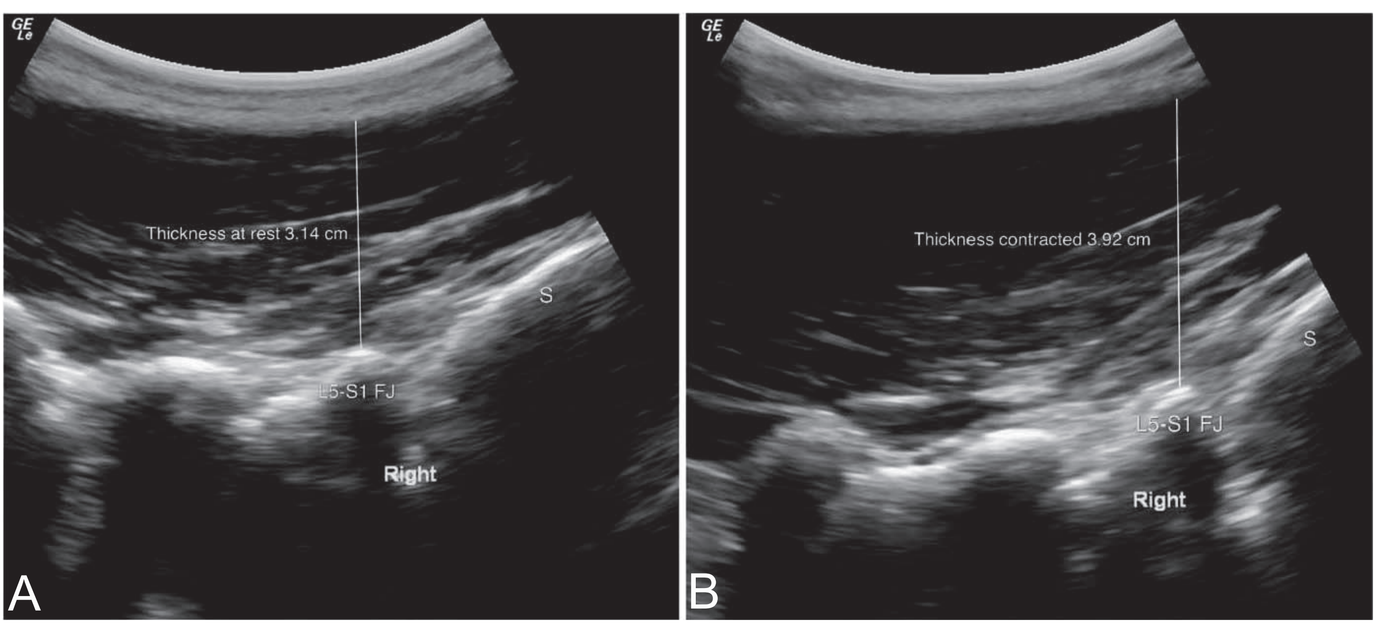

Figure 2. Lumbar multifidus muscle thickness measurement at L5-S1. A, at rest and B, during contraction via a contralateral arm lift in a prone position. The facet joints (FJ) of L5–S1 were used as landmarks for the lower borders of the muscle. Abbreviation: S, sacrum.

ness on contraction – Thickness at rest)/Thickness at rest) × 100]. The LM EI measurements were obtained with ImageJ imaging software (version 1.49; National Institutes of Health, Bethesda, MD) using the standard histogram grayscale analysis function (eg, pixels expressed as value between 0 [black] and 255 [white]). Greater EI indicates a larger amount of intramuscular fat and connective tissue. The EI measurement was acquired by tracing the LM muscle CSA on the prone images, without including bone or surrounding fascia.[15] Again, the average value of the 3 measurements from 3 different images was used in the analyses. An experienced athletic therapist researcher with extensive experience in analyzing spine images acquired all the ultrasound measurements (eg, blinded to players' characteristics and history of injury). The intrarater reliability (intraclass correlation coefficients [ICCs] 3,1) of the same rater was reported in a previous study[15] and varied between 0.96 and 0.99 for all measurements.

Dual-Energy X-Ray Absorptiometry

During the same session, a full-body DEXA scan (Lunear Prodigy Advance, GE Healthcare, Madison, WI) was performed on each player by a certified medical imaging technologist. Before imaging, all players removed any metal and were required to wear loose-fitting clothing to avoid interference with the DEXA scan. The following demographic characteristics were entered in the computer software before imaging: age, height, weight, and ethnicity. Participants were supine in the center of the scanner with their arms slightly away from the body, thumbs pointing upward, and legs slightly apart with toes pointing upward. The following composition measurements were used in the analysis: total lean mass, total bone mass, total fat mass, and total percentage of body fat.

Statistical Analysis

We calculated descriptive statistics (eg, means and standard deviations) for players' characteristics and independent *t* tests to compare demographic and anthropometric characteristics between male and female players. Paired *t* tests were used to assess differences in LM characteristics between the right and left sides (within women and men). Analysis of variance was computed to assess differences in LM characteristics between female and male players. We examined possible differences in LM muscle measurements between players with and those without LBP or lower limb injury using analysis of covariance using weight, height, and total percentage of body fat to adjust for anthropometric differences. Finally, the relationship between LM muscle characteristics and body composition measurements was evaluated using Pearson correlation and linear regression models. All analyses were performed using STATA software (version 12.0; StataCorp LLC, College Station, TX).

RESULTS

Participants' characteristics are presented in Table 1. Mean age, height, and weight were 21.4 ± 1.8 years, 171.2 ± 7.4 cm, and 75.0 ± 10.1 kg, respectively. Differences in anthropometric and body composition measurements were found between female and male players. The players averaged 5.1 ± 2.9 years playing rugby at a competitive level and ranged from their first to fifth year at the university level.

Lumbar Multifidus Muscle Characteristics

The prone and standing LM muscle measurements of interest for the right and left sides in female and male players are presented in Table 2. The LM CSA and thickness at rest and during contraction in both prone and standing positions were greater in male than in female players. The LM EI was larger in women than in men ($P <$ .002). The CSA asymmetry and percentage of change in thickness during contraction were not different in prone or standing position between female and male participants. The prone and standing LM CSA was larger on the left side than on the right side in women. Lumbar multifidus thickness at rest and during contraction in prone and standing positions was greater on the left than on the right side in men.

Low Back Pain and Lower Limb Injury

The percentage change in thickness during contraction while standing was less in players who reported LBP in the previous 3 months ($F = 5.21$, $P = .03$) compared with players who had no LBP (Table 3). The LM CSA side-to-side asymmetry (right versus left) was greater in players who reported a lower limb injury in the previous 12 months ($F = 4.98$, $P = .03$) than in players without such a history (Table 4).

Associations Between LM Muscle Characteristics and Body Composition

The LM muscle CSA was significantly correlated with height ($r = 0.69$, $P < .001$; $r = 0.69$, $P < .001$) weight ($r = 0.50$, $P = .002$; $r = 0.50$, $P = .02$), total bone mass ($r = 0.75$, $P < .001$; $r = 0.75$, $P < .001$),and total lean mass ($r = 0.74$, $P < .001$; $r = 0.66$, $P = .001$) in prone and standing positions, respectively. Similar significant correlations were observed for LM thickness at rest and LM thickness during contraction in both positions. Body mass index was not correlated with LM CSA in the prone ($r = 0.07$, $P = .66$) or standing ($r = 0.14$, $P = .54$) position. The LM EI was strongly correlated with the total percentage of body fat ($r = 0.84$, $P < .001$) and total lean mass ($r = -0.55$, $P < .001$). The association between LM EI and total percentage of body fat remained significant after adjustment for sex ($P < .001$, $R^2 = 0.69$; Figure 3). When we adjusted for sex, a trend was noted between greater LM EI and less LM percentage change in thickness during contraction in prone position ($P = .05$, $R^2 = 0.31$) Finally, the percentage of change in thickness during contraction in the prone and standing positions was significantly associated with the total percentage of body fat ($P = .03$, $R^2 = 0.12$).

DISCUSSION

Lumbar Multifidus Muscle Characteristics

In accordance with a previous study,[15] our results showed that LM muscle CSA in a prone position was larger in male athletes than in female athletes. Hypertrophy of the LM muscle in both our male and female rugby players was

Table 1. Participants' Characteristics

Characteristic	All (n = 34)	Women (n = 20)	Men (n = 14)	*P* Value[a]
Age, y (mean ± SD)	21.4 ± 1.8	21.7 ± 1.9	20.9 ± 1.6	.13
Height, cm (mean ± SD)	171.2 ± 7.4	167.6 ± 5.4	176.3 ± 7.0	<.001
Weight, kg (mean ± SD)	75.0 ± 10.1	71.3 ± 8.7	80.3 ± 9.9	.01
Total lean mass, kg (mean ± SD)	54.0 ± 9.2	48.5 ± 5.6	61.9 ± 7.5	<.001
Total bone mass, kg (mean ± SD)	3.0 ± 0.4	2.9 ± 0.03	3.4 ± 0.4	<.001
Total fat mass, kg (mean ± SD)	18.3 ± 6.5	20.19 ± 6.7	15.5 ± 5.4	.03
Total body fat, % (mean ± SD)	25.2 ± 7.7	28.9 ± 7.1	19.9 ± 5.2	<.001
Body mass index (mean ± SD)	25.5 ± 2.5	25.3 ± 2.7	25.8 ± 2.3	.63
Dominant leg, No.				
Right	30	18	12	
Left	3	2	1	
Either	1	0	1	
Position, No.				
Forward	19	12	7	
Back	15	8	7	
Rugby competitive level, y (mean ± SD)	5.1 ± 2.9	5.0 ± 2.7	5.4 ± 3.2	.96
Rugby university level, y (mean ± SD)	1.8 ± 1.6	2.3 ± 1.7	1.1 ± 1.2	.47
LBP in previous 3 mo, No.	14	7	7	
LBP in location 3 mo, No.				
Centered	8	5	3	
Bilateral	3	1	2	
Unilateral	3	1	2	
LBP intensity (0–10) over previous 3 mo (mean ± SD)	4.1 ± 2.1	4.0 ± 2.1	4.1 ± 2.2	.90
Lower limb injury over previous 12 mo, No.	13	9	4	
Lower limb injury in previous 12 mo by body part, No.				
Ankle	5	3	2	
Thigh	3	2	1	
Knee	4	3	1	
Hip	1	1	0	

Abbreviation: LBP, low back pain.

[a] Independent *t* tests were used to compare demographic and anthropometric characteristics between female and male players.

evident, as the resting LM CSA was larger than in nonathletic healthy participants of slightly greater age.[21] The resting prone LM CSA of our male participants was comparable with that of elite male weightlifters (10.95 ± 0.31 cm^2) of similar age (21.49 ± 0.59 years) and body size[22] as well as university-level male hockey players (CSA = 9.84 ± 1.39 cm^2, age = 21.4 ± 1.4 years, height = 181.8 ± 6.2 cm, weight = 86.7 ± 6.8 kg)[15] and professional AFL players (age = 21.9 ± 3.6 years, CSA = 9.14 ± 1.65 cm^2, height = 188.4 ± 7.3 cm, weight = 90.4 ± 5.6 kg).[9] However, our female participants displayed slightly less resting LM CSA than did elite female weightlifters (CSA =

Table 2. Lumbar Multifidus Muscle Characteristics of Female and Male Rugby Players (Mean ± SD)[a,b]

Position and Variable	Women (n = 20)		Men (n = 14)	
	Right	Left	Right	Left
Prone				
CSA, cm^2	**7.45 ± 1.08[a]**	**7.80 ± 1.23**	**10.24 ± 1.15**	**10.41 ± 1.26**
CSA asymmetry, %	5.18 ± 3.99		3.00 ± 2.28	
Echo intensity, arbitrary units	**71.60 ± 19.89**	**70.26 ± 16.20**	**52.97 ± 12.03**	**53.67 ± 12.64**
Thickness, cm				
Rest	**2.62 ± 0.35**	**2.71 ± 0.41**	**3.08 ± 0.27[a]**	**3.27 ± 0.36**
Contracted	**3.06 ± 0.49**	**3.17 ± 0.57**	**3.63 ± 0.37[a]**	**3.82 ± 0.45**
Percentage change	16.47 ± 7.02	16.80 ± 8.60	17.71 ± 6.47	17.01 ± 8.16
Standing				
CSA, cm^2	**8.72 ± 1.05[a]**	**9.02 ± 1.10**	**12.06 ± 1.46**	**12.17 ± 1.44**
CSA asymmetry, %	3.95 ± 2.76		2.69 ± 2.52	
Thickness, cm				
Rest	**3.04 ± 0.45**	**3.09 ± 0.47**	**3.57 ± 0.38[a]**	**3.72 ± 0.46**
Contracted	**3.19 ± 0.47**	**3.23 ± 0.55**	**3.76 ± 0.39[a]**	**3.91 ± 0.45**
Percentage change	5.14 ± 5.27	4.37 ± 3.65	5.56 ± 5.17	5.52 ± 4.67

Abbreviation: CSA, cross-sectional area.

[a] Indicates difference (*P* < .05) between the right and left sides of female or male players.

[b] Boldface values indicate difference (*P* < .05) between female and male players.

Table 3. Lumbar Multifidus Muscle Characteristics (Mean [Standard Error]) Between Players With and Those Without Low Back Pain Within Previous 3 Months

	Low Back Pain	
Position and Variable	No (n = 20)	Yes (n = 14)
Prone[a]		
CSA, cm^2	8.59 (0.29)	9.02 (0.36)
CSA asymmetry, %	4.29 (0.82)	4.22 (1.04)
Echo intensity, arbitrary units[b]	63.64 (2.20)	64.91 (2.78)
Thickness, cm		
Rest	2.85 (0.08)	2.91 (0.10)
Contracted	3.37 (0.11)	3.35 (0.13)
Percentage change	18.04 (1.67)	15.33 (1.99)
Standing[a]		
CSA, cm^2	9.90 (0.35)	10.79 (0.44)
CSA asymmetry, %	3.41 (0.59)	3.48 (0.74)
Thickness, cm		
Rest	3.26 (0.10)	3.37 (0.12)
Contracted	3.46 (0.11)	3.48 (0.13)
Percentage change	**6.16 (0.77)**	**3.40 (0.92)**

Abbreviations: CSA, cross-sectional area.

[a] Adjusted means for height and weight.

[b] Adjusted means for total percentage of body fat.

[c] Indicates difference.

Table 4. Lumbar Multifidus Muscle Characteristics (Mean [Standard Error]) Between Players With and Those Without Lower Limb Injury in Previous 12 Months

	Lower Limb Injury	
Position and Variable	No (n = 21)	Yes (n = 13)
Prone[a]		
CSA, cm^2	8.90 (0.29)	8.54 (0.36)
CSA asymmetry, %	**3.20 (0.76)**[c]	**5.91 (0.94)**
Echo intensity, arbitrary units[b]	63.98 (2.18)	64.38 (2.71)
Thickness, cm		
Rest	2.88 (0.08)	2.87 (0.10)
Contracted	3.38 (0.11)	3.35 (0.14)
Percentage change	17.01 (1.65)	16.78 (2.10)
Standing[a]		
CSA, cm^2	10.44 (0.35)	9.94 (0.44)
CSA asymmetry, %	3.56 (0.58)	3.25 (0.73)
Thickness, cm		
Rest	3.29 (0.10)	3.32 (0.13)
Contracted	3.46 (0.11)	3.48 (0.13)
Percentage change	5.35 (0.80)	4.51 (1.02)

Abbreviation: CSA, cross-sectional area.

[a] Adjusted means for height and weight.

[b] Adjusted means for total percent age of body fat.

[c] Indicates difference.

8.65 ± 0.32 cm^2)[22] or university-level female hockey players (CSA = 8.98 ± 1.19 cm^2, age = 21.3 ± 1.8, height = 167.7 ± 5.6 cm, weight = 67.7 ± 7.8 kg).[15] This hypertrophy likely resulted from the high physical demands and postural requirements associated with the sport. Indeed, the LM muscle is highly active when performing *anticipatory postural adjustments*, defined as involuntary and automatic adjustments generated during a disturbance in a predictable posture.[23] Such postural adjustments are crucial in rugby as they allow athletes to maintain their base of support while stabilizing the vertebral segments. The deep and superficial LM muscle fibers have different activation mechanisms; the deep fibers control intervertebral movement, whereas the superficial fibers control spinal orientation.[24] In tasks such as tackling, rucking, and scrummaging, athletes must lean forward and maintain a strong position for a few seconds against external perturbations from other players. In other tasks, such as passing and catching, the athletes need to keep their arms and hands up (shoulder flexion) at all times. Rapid shoulder flexion is preceded by activation of the superficial fibers of the LM before muscular activity of the shoulder flexors.[23] As such, the LM hypertrophy we observed is likely a response or adaptation to the specific physical demands of the sport.

Resting LM thickness in the prone position was similar to findings of previous studies[2,8,9,13–15] conducted in athletes, and the percentage changes in thickness in female (16.64% ± 7.81%) and male (17.36% ± 7.32%) rugby athletes was congruent with values reported in healthy nonathletic participants (17.46% ± 9.20%)[17] as well as university-level hockey players (men = 17.10% ± 8.91%, women = 13.47% ± 5.74%).[15] The LM CSA and thickness measurements were greater in standing position than in prone position among both sexes. Indeed, when the individual stands in a functional weight-bearing position, the LM contracts to provide spinal stability and maintain an upright posture, allowing for the characterization of LM morphology while contracted in a stabilizing role. Accordingly, the LM percentage change in thickness (eg, contraction) was also smaller than in prone position, a finding that is consistent with previous results in athletic[15]

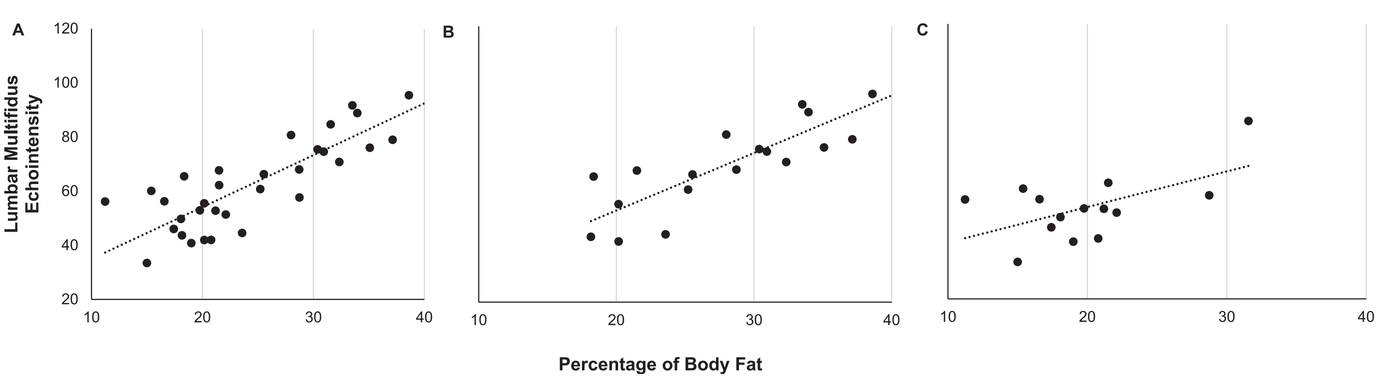

Figure 3. Correlation between A, multifidus muscle echo intensity (EI) and the total percentage of body fat acquired via dual-energy X-ray absorptiometry, and correlation between multifidus muscle EI and the total percentage of body fat by sex: B, women; C, men.

and nonathletic[17] populations. Furthermore, women demonstrated greater LM CSA (prone and standing positions), whereas men had greater LM thickness on the left side. Handedness[25] has been associated with LM asymmetry at the L5-S1 level. Kicking, an asymmetric ballistic task, is a skill required by most rugby players. When kicking with the dominant leg, the athlete plants the contralateral leg to stabilize his or her motion. High numbers of repetitions of this movement over the years may have contributed to the observed LM hypertrophy in favor of the nondominant side. Hides et al[26] came to a similar conclusion and reported that the quadratus lumborum muscle in elite AFL players was larger on the side contralateral to the kicking leg. Although the LM was larger on the left side, the mean side-to-side asymmetry in the prone position was <5%, which corroborates previous descriptions in athletes.[8,15,22] Side-to-side CSA asymmetry was slightly less when measurements were obtained in the standing position, suggesting that the asymmetry may be more structural than functional.

Low Back Pain

When we assessed LM muscle characteristics according to LBP, no differences were present for LM CSA or side-to-side asymmetry between players with and those without LBP. Although smaller LM CSA and greater asymmetry have been identified in elite athletes with LBP,[7,14,15] other researchers found no deficits.[22,27] Thus, athletic populations may behave differently with regard to LM morphology and LBP, possibly due to competing influences, such as specialized movements and specific training effects.[27] However, our results revealed a decreased ability (smaller LM percentage change in thickness) to contract the LM in the standing position among athletes who reported LBP in the previous 3 months. Given that the LM plays a critical role in lumbopelvic stability, including trunk control and the transfer of forces and motion through the kinetic chain, a deficit in neuromuscular control while performing a functional task may have detrimental effects on spinal stability and contribute to injury susceptibility.

Lower Limb Injury

Rugby players who sustained a lower limb injury in the previous 12 months had greater LM side-to-side asymmetry (prone position) than uninjured players. This finding corroborates that of Hides et al[9] involving elite AFL players. Lumbar multifidus CSA was also reported to relate to the severity of hip, groin, or thigh injury,[28] yet our results did not support this result. Athletes with LBP have a wide array of motor-control impairments, including alterations in the kinetics, kinematics, and strength of both the trunk and lower limbs,[5] and such dysfunctions should also be considered when evaluating the relationships among LM, LBP, and lower limb injury. This is particularly important when evaluating the relationship between LBP and lower limb injuries. Future authors should evaluate whether LBP is a predictor of lower limb injury.

Associations Between LM Muscle Characteristics and Body Composition

The LM CSA and thickness were positively and significantly associated with the athletes' height, weight, total bone mass, and total lean mass in the prone and standing positions. Body mass index was not correlated with LM CSA or LM EI. Our findings are very similar to and corroborate those of a related study in university-level hockey players.[15] Also, in accordance with Fortin et al,[15] LM EI was greater in women and strongly correlated with total lean mass, total fat mass, and total body fat percentage. Although we only observed a trend between greater LM EI and a smaller percentage of change in thickness in the prone position, we demonstrated a significant negative correlation between the percentage of change in thickness and the total percentage of body fat. This result indicates that athletes with a greater overall percentage of body fat were less able to contract the LM muscle. Although previous researchers[29,30] showed significant associations among muscle EI, muscle strength, and power in middle-aged and elderly participants, the relationship among LM muscle morphology, body composition, and muscle function warrants further attention.

Our sample size was similar to the samples of other investigations conducted on elite-level athletes but was still relatively small, which was a limitation. Future researchers should study larger samples and more elite-level teams to establish the generalizability of our results. Even though EI is a valid and reliable indicator of intramuscular fat and connective tissue, this measure does not provide a precise estimation of the percentage of fatty infiltration.

CONCLUSIONS

We provided novel normative data on LM muscle morphology and dynamic activation and demonstrated changes in LM characteristics in different postures (ie, prone versus standing) in university rugby players. The muscular response to postural demands was different between players with and those without LBP; the former displayed less active contraction in the standing position. Lower limb injury was associated with greater LM CSA side-to-side asymmetry. Lumbar multifidus morphology and function were highly correlated with DEXA body composition measurements, offering additional evidence that body composition should not be ignored when studying this muscle in athletic populations. Future authors should explore LM neuromuscular control and thickness modulation in functional positions (such as standing) in athletes and whether targeted rehabilitation interventions are effective for ameliorating LM dynamic stability and injury rates.

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