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Measurement of Lumbar Multifidus Asymmetry in Amateur Cricket Pace Bowlers using Real-Time Ultrasound

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ABSTRACT

International Journal of Exercise Science 11(3): 875-885, 2018. Objectives: To determine if lumbar multifidus asymmetry existed between the fifth lumbar (L5) and 1st sacral (S1) spinal level in a group of amateur cricket pace bowlers and a healthy non-cricketing group of males, and to determine if there were significant differences between groups in lumbar multifidus asymmetry at rest, on contraction, or during activation. Design: A prospective single blinded cross-sectional study. Methods: Forty healthy participants were recruited to two groups: an amateur cricket pace bowling group (n=20) and a non-cricketing group (n=20). Bilateral real-time ultrasound imaging of lumbar multifidus was conducted at the L5/S1 level in a resting and contracted state. Muscle thickness was measured and percentage activation was calculated. A force probe device was used to standardise force, inclination and roll of the ultrasound probe during real-time ultrasound imaging. Results: There was evidence of asymmetry in both groups, but differences between dominant and non-dominant sided lumbar multifidus thickness were non-significant. Between group comparisons of lumbar multifidus asymmetry indicated no significant difference for rest or activation. However, the cricket group had a significantly greater asymmetry of lumbar multifidus when contracted compared to controls (p=0.04). Conclusions: The results indicate that amateur cricket pace bowlers had significantly greater contracted lumbar multifidus asymmetry than non-cricketers. The resting lumbar multifidus asymmetries demonstrated previously in elite pace bowlers were not found in this population. Future research should investigate lumbar multifidus asymmetry in amateur pace bowlers in relation to lower back injury, and make comparisons between amateur and elite cricket pace bowlers.

KEY WORDS: Paraspinal muscles, sports, ultrasonography, physical therapy speciality

INTRODUCTION

Cricket is an outdoor sport involving a contest between bat and ball (16). Bowlers hurl the ball down the pitch in the attempt to dismiss the batsman. To complete a delivery (a singular bowl) bowlers must perform a complex but synchronised array of asymmetrical limb and trunk movements (17). There are two types of bowlers: pace and spin. Pace bowlers approach the pitch and release the ball at speed, meaning forces of up to six times body weight are transmitted through the lower limbs and back of the bowler, whereas spin bowlers utilise a slow approach and attempt to spin the ball through the air to deceive the batsman (2). The high speed and resultant increase in force withstood by a pace bowler on delivery contributes to their injury risk being the highest of all cricketers, with one quarter of bowlers sustaining injury, predominantly in the low back region (16). Injuries sustained by pace bowlers are more prevalent on the non-bowling side of the body (18). It has been suggested that the asymmetrical injury distribution is reflective of asymmetries in stability muscle size and strength in pace bowlers, with both attributable to the unique biomechanics of pace bowling (24).

Side to side differences in muscle size, strength or function are termed asymmetry. Asymmetry may be evidence of muscle composition alteration and atrophy, or a normal occurrence in certain populations. Investigating stability muscle symmetry in sportspeople is highly important because understanding baseline trends in sporting groups can guide muscle conditioning and intervention programs (7). A particular muscle of focus in previous symmetry studies in both elite cricketing and non-sporting populations was lumbar multifidus (LM), which primarily acts to provide stability to the zygapophyseal joints of the lumbar spine (20). Additionally, it has been suggested that LM's contribution to lumbar proprioception and neuromuscular control may prevent the occurrence of lower back pain (LBP) by providing local lumbar stability even in the presence of anatomical or mechanical deficits (7, 8, 20).

Studies of LM symmetry have identified side to side differences in size in both sporting and non-sporting populations, with the most difference being found at L5 (9). Predisposing factors for the development of LM asymmetries include handedness, familial aggregations and LBP (3). Asymmetry of LM size and function has the potential to cause reductions in stability and contribute to injury, especially in sportspeople (19). While LM asymmetry and LBP have been linked, a causative relationship between the two remains unclear (10).

LM asymmetry has been investigated using real-time ultrasound imaging (RTUI) and magnetic resonance imaging (MRI). RTUI has benefits over MRI including better accessibility, ease of transport, time and cost effectiveness, and discipline applicability to a suitably trained physiotherapist (11). A systematic review found evidence that RTUI is valid and reliable for measurement of LM thickness and activation asymmetry (4). Measurement of LM thickness has been reported in a non-contracted 'Resting' state (R_{LM}), during contraction in its 'Contracted ' state (C_{LM}), and as a percentage change or ratio of rest to contraction thickness which represents activation (A_{LM}) (4). LM size can be imaged in prone or standing, with LM contraction elicited with a weighted or unweighted contralateral arm lift (CAL) (15, 23).

However, it has been suggested that intra-examiner and inter-examiner measurement differences can occur when there are variations of RTUI probe application force and angle of scanning (21, 25). Differences in these variables have the potential to distort images produced during RTUI and cause measurement bias (5, 12). Therefore, standardisation of RTUI probe forces can improve between-scan measurement reliability.

Existing literature investigating LM asymmetry in cricketers has focused on elite populations and neglected amateur cricketers, who inherit a high injury risk suggested to result from their lesser participation in cricket specific training and other conditioning activities (22). Elite cricketers are those who play at a domestic or international level, whereas amateurs participate at a regional or club level (22). No studies to date have investigated asymmetry of LM in amateur cricket pace bowlers despite their high injury risk.

Therefore, this study aimed to investigate LM thickness asymmetry under the three conditions of R_{LM}, C_{LM}, and A_{LM}, and make comparisons between amateur cricket pace bowlers and a healthy non-cricketing population. RTUI was conducted using a force probe device (FPD) (6) to standardise intra-participant probe position and pressure. Based on previous findings in elite pace bowlers, it was hypothesised that amateur cricket pace bowlers would have significant dominant to non-dominant side asymmetry of LM, and significantly greater asymmetry compared to the control group. For the purpose of this study, the dominant side was defined as the bowling arm for the cricket group and the preferred throwing arm for the control group.

METHODS

Participants
Forty-one male participants aged 16 to 38 years were recruited to two groups: cricket and control. One control was excluded from data collection because they did not satisfy the exclusion criteria. All participants were injury and pain free at the time of data collection. Participants were sampled by convenience sampling. Twenty pace bowlers in the local A-Grade and Reserve Grade cricket competition were included in the cricket group, while twenty non-cricketing individuals were included in the control group. Exclusion criteria were: contraindications to RTUI including skin conditions in the scanning region, low back pain three months prior to data collection, current symptomatic low back pathology or congenital abnormalities, specific spinal stabilisation training for LM three months prior to data collection, previous spinal surgery, and previous or current spinal cord or cauda equina injury or abnormality. Controls were also excluded if they participated in cricket or any other sports involving asymmetrical upper limb activity such as golf and tennis. Ethical approval was granted by the Human Ethics Committee of the tertiary education institution (HREC number: H6354) and all participants were provided with verbal and written information before giving written informed consent for participation.

Protocol
Prior to the commencement of data collection, the examiner was trained in RTUI. An intra-examiner reliability study demonstrated near-perfect reliability, *ICC* 0.961 (*CI* 0.894 – 0.962).

All data collection was completed in private physiotherapy rooms of a tertiary education institution. The full set-up of equipment is demonstrated in Figure 1. On arrival participants filled out a details form, removed their shoes, socks and shirt, had their height and weight measured, and loosened their waist band of their trousers to expose S2. The examiner palpated and marked L4 and L5 spinous processes with a body marker. Participants were standing up for data collection.

RTUI was completed using a Venue 40 Model R1.x.x (GE Healthcare, Jiangsu, P.R. China), with a 5MHz convex array probe and footswitch attached. A FPD device, comprised a digitally printed external probe casing, which relayed and stored real time force, inclination and roll data from the RTUI probe using the LabVIEW virtual instrument link on a laptop computer (6). The casing attached directly to the outside of the RTUI probe (6). Ultrasonic transmission gel and a protective sheath (GE Healthcare Australia Pty Limited) covered the PFD casing and RTUI probe. During imaging, data and video signals were activated, relayed and stored simultaneously for later extrapolation.

The examiner applied the RTUI probe in a sagittal orientation on the patient's skin at the level of L4/5 and then moved the probe laterally. The longitudinal RTUI view identified the spinous process of L5 and the sacrum to provide a clear image of LM at L5/S1 level (Figure 2), where previous literature identified LM to be the most asymmetrical (9). This view has been cited to represent the "Lochness Monster" and is the optimal view to image and measure LM (24) (Figure 2). The probe position to produce the Lochness Monster was then marked on the participant's skin and the process repeated on the other side. The FPD parameters (force, inclination and roll) required to produce the optimal view of LM were documented for both sides. These FPD parameters were different for each individual because of each person's differences in muscle, skin and fat composition. Therefore, the FPD data parameters were recorded separately.

Before commencing all RTUI participants were asked to march on the spot for five seconds then stop and remain still with hands by their side to standardise their position. This position was maintained throughout scanning (24). RTUI movies were captured for R_{LM} and C_{LM}. To image left R_{LM}, a RTUI movie of LM at L5/S1 was captured in B mode simultaneously with FPD data, while maintaining FPD parameters in the range documented. Both were stopped simultaneously and stored. This was repeated on the right side.

A preliminary study on three volunteer non-cricketers identified that a CAL to 90 degrees glenohumeral flexion with the addition of approximately 5% body weight produced a consistent LM contraction. The consistency of contraction was defined qualitatively using RTUI. To ensure participants lifted the weight to the correct level, a goniometer was used to measure 90 degrees glenohumeral flexion. A line was marked at this level on a whiteboard in front of the participant prior to the start of RTUI. To commence data collection of left C_{LM} (meaning the left LM muscle is being activated), RTUI and FPD data capture were simultaneously started and then the participant was instructed to perform the weighted CAL while holding a hand weight approximately 5% of their body weight in their right hand. Again, the FPD parameters were maintained in the range documented. Once RTUI was completed, the participant lowered their arm. Right C_{LM} was imaged in the same way, but instead a left weighted CAL was performed. RTUI and FPD data were stored following each session for later analysis.

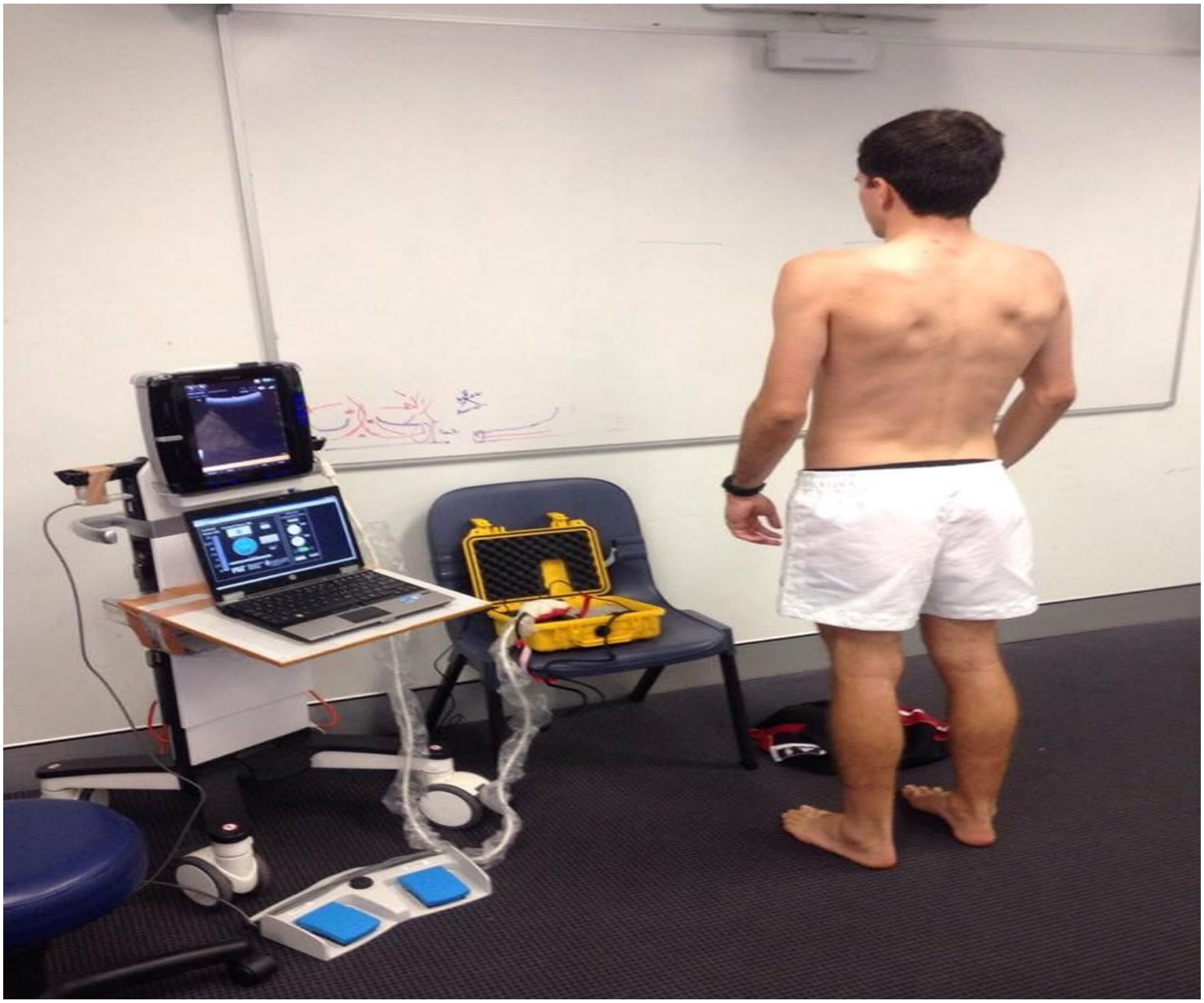

Figure 1: Full room set up with participant starting position demonstrated. The RTUI device is switched on with the FPD attached. The participant has removed socks, shoes and shirt, and has performed a 5 second 'march' on the spot to standardise standing position.

FPD data was matched to RTUI movies by opening them in Microsoft Excel© and VideoPad© (NCH Software, 2016) respectively. FPD parameters analysed were for force (N), inclination (degrees), and roll (degrees). FPD data was matched for force, inclination and roll for left R_{LM} and C_{LM}, and right R_{LM} and C_{LM} separately. Any time points where force, inclination and roll were matched between R_{LM} and C_{LM} were flagged. Two time points for left R_{LM} and C_{LM} data were documented. The process was repeated for the right side data. A still image was captured at each time point where force, inclination and roll were matched. An independent research assistant de-identified and randomised all images (n=320) to blind the examiner prior to measurement.

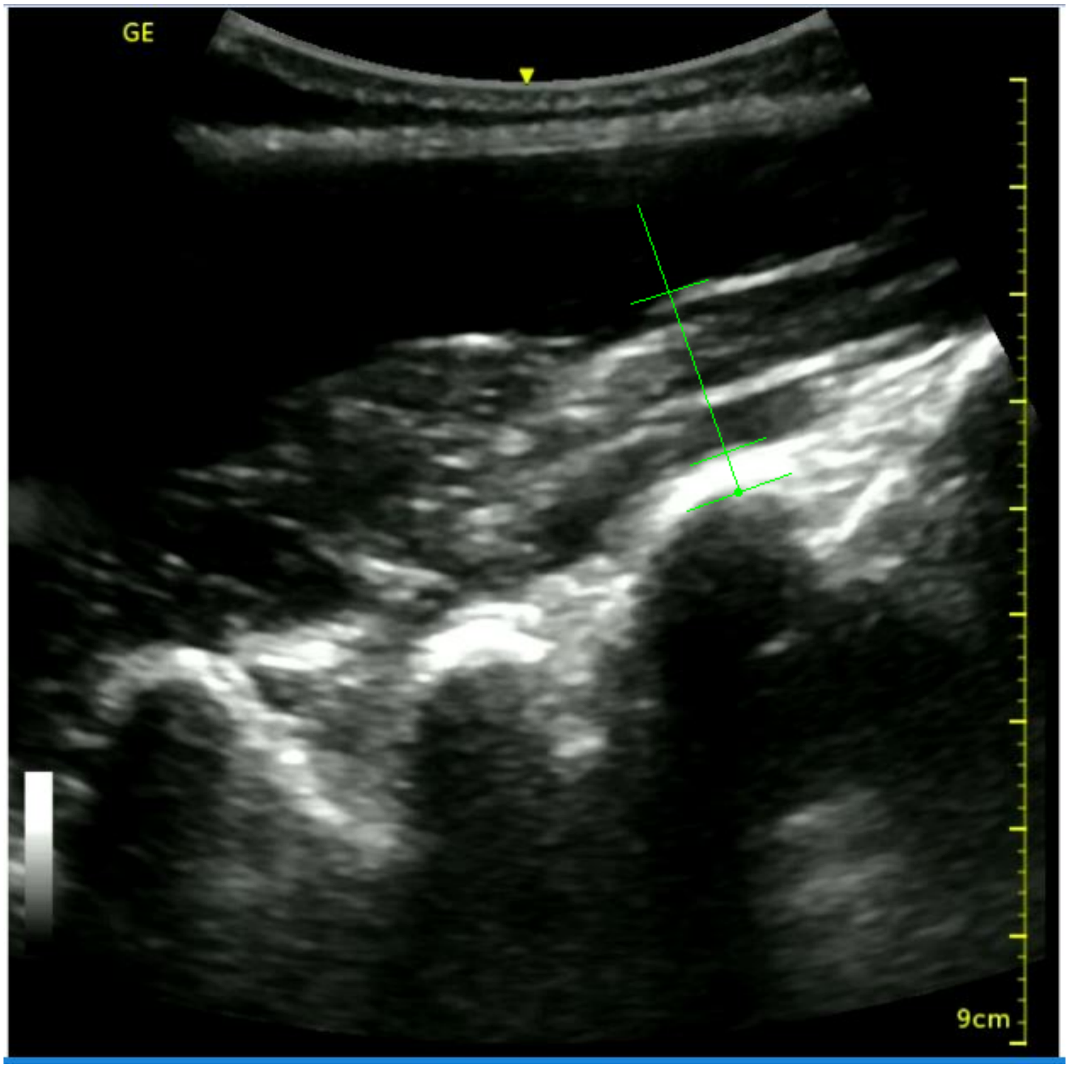

Figure 2: The Lochness Monster figure identified in RTUI imaging of L5/S1.

LM thickness was measured using ImageJ© software Version 1.51a (National Institutes of Health, https://imagej.nih.gov/ij/index.html). The L5/S1 zygapophyseal joint and thoracolumbar fascia were identified. A line perpendicular to the surface of the L5/S1 zygapophyseal joint was used to measure LM thickness (cm) from the most superficial aspect of the zygapophyseal joint to the most superficial aspect of the thoracolumbar fascia.

Following blinded measurement, all LM measurements were de-randomised by the independent research assistant and were inputted into an Excel spreadsheet. BMI was calculated for each participant by dividing weight (kg) by height squared (m) (1). R_{LM} and C_{LM} thickness was measured as a distance in centimetres. A_{LM} was calculated using the formula: $A_{LM} = \frac{C_{LM} - R_{LM}}{R_{LM}} \times 100$ as the percentage difference between R_{LM} and C_{LM} (23). Asymmetry was calculated as the difference between dominant and non-dominant sided measurements for R_{LM}, C_{LM} and A_{LM}. For the purpose of this study, the dominant side was defined as the bowling arm for the cricket group and the preferred throwing arm for the control group.

Statistical Analysis
Sample size was calculated using Altman's nomogram with a relevant difference of 2.2%, standard deviation of 2.5, alpha of .05 and power of .8. All statistical tests were performed using IBM SPSS Statistics, version 23 (SPSS Inc., Chicago, IL, USA)© with alpha set at p=0.05. Independent samples T-tests were used for parametric data and reported as Mean ± SD. Mann-Whitney U tests were performed for non-parametric data and reported as Median (IQR).

RESULTS

Normally distributed demographic characteristics including age, weight, height and BMI were analysed for between group differences. No significant differences were found for height (p=0.05), weight (p=0.20) and BMI (p=0.81), but the cricket group was significantly older than the control group (p=0.004) (Table 1). The cricket group trended towards having larger dominant sided LM thickness at R_{LM} (p=0.22), C_{LM} (p=0.38), and A_{LM} (p=0.88) (Table 2). The control group trended towards having larger dominant sided R_{LM} (p=0.43), but LM was larger on the non-dominant side for C_{LM} (p=0.39) and A_{LM} (p=0.09) (Table 3). There were no significant differences between cricket and control groups for R_{LM} (p=0.52) or A_{LM} (p=0.25) asymmetry, but significant differences existed between groups for C_{LM} asymmetry (p=0.046) (Table 4).

Table 1. Participant demographic characteristics and statistical differences between groups.

	All^	Cricketers^	Controls^	p [CI]
Age (years)	22.23 ± 4.36	24.20 ± 5.16	20.25 ± 2.07	0.004*[1.39, 6.51]
Height (cm)	182.05 ± 7.39	184.33 ± .12	179.78 ± 7.11	0.050 [-0.01, 9.11]
Weight (kg)	84.98 ± 12.86	87.61 ± 13.47	82.35 ± 11.98	0.200 [-2.90, 13.42]
BMI	25.63 ± 3.48	25.76 ± 3.42	25.49 ± 3.62	0.807 [-1.98, 2.53]

*Statistically significant difference (p<0.05); ^Reported as Mean ± SD

Table 2. Cricket group measurements of LM in all three states.

	Dominant side	Non-dominant side	Asymmetry
R_{LM} (cm)	2.22 ± 0.48^	2.03 ± 0.49^	0.27 (0.85)#
C_{LM} (cm)	2.23 ± 0.33^	2.12 ± 0.48^	0.09 (0.68)#
A_{LM} (%)	1.69 (21.67)#	-.09 (24.02)#	0.51 (28.85)#

*Statistically significant difference (p<0.05). ^Represented as Mean ± SD. #Represented as Median (IQR)

Table 3. Control group measurements of LM in all three states.

	Dominant side	Non-dominant side	Asymmetry
R_{LM} (cm)	2.08 ± 0.48^	1.95 ± 0.56^	0.04 (0.66)#
C_{LM} (cm)	2.00 ± 0.40^	2.12 ± 0.48^	-0.13 (0.31)#
A_{LM} (%)	-4.67 (25.72)#	12.26 (29.66)#	-15.40 (52.52)#

*Statistically significant difference (p<0.05). ^Represented as Mean ± SD. #Represented as Median (IQR)

Table 4. Between group differences in asymmetry.

	Between group differences in asymmetry~
R_{LM}	0.529 [-0.27, 0.37]
C_{LM}	0.046 [0.01, 0.50]*
A_{LM}	0.253 [-6.38, 29.31]

*Statistically significant difference (p<0.05). ~Represented as P [CI]

DISCUSSION

The aims of this study were to determine if LM asymmetry existed in amateur cricket pace bowlers and non-cricketers, and if any observed asymmetry was significantly different between groups. It was hypothesised that amateur pace bowlers would demonstrate LM asymmetry which would be significantly larger than non-cricketers. This was the first study, to the investigator's knowledge, which investigated LM symmetry in amateur cricket pace bowlers using RTUI, and standardised probe force, inclination and roll with the addition of a FPD. Results revealed significant differences in LM asymmetry between groups for C_{LM}.

Previous studies have identified significant asymmetries of LM in elite cricket pace bowlers (9) and non-cricketers (23), which were not found in this study. However, the amateur bowlers had a trend towards larger dominant sided LM in all states, which was a trend reflective of results in previous literature (7, 19). Since dominant sided LM has been identified as larger in both amateur and elite cricketing populations, this trend may be an inherent characteristic of pace bowler stability muscle morphology. Asymmetry was significantly different between groups for C_{LM}. However, participants had a large variance of LM recruitment patterns. While the mechanism causing this is unclear, perhaps the variability of LM contraction between participants widened variation of results, meaning intra-group trends were less likely to be found.

With the exception of age, participants demonstrated similar demographic characteristics. While there was a significant age difference between groups, previous studies reported no association between age and LM size and therefore this may have had minimal effect on results (10, 21). Although this study's results demonstrated non-significant differences in either group, the findings provide a baseline understanding and contribute to the knowledge on LM asymmetry of size and activation without the presence of injury or pain. Further research is required to determine whether this trend is found in other amateur cricketing and sporting populations.

The completed study utilised a weighted CAL to elicit LM contraction and found asymmetries for C_{LM} to be significantly larger in the cricket group. Sweeney, O'Sullivan, & Kelly also measured LM contraction using a CAL in chronic LBP patients and a healthy population (23). While the populations were different, both studies found significant differences in C_{LM} asymmetry between groups, with the healthy population demonstrating significantly less asymmetry than the respective other groups. It is important to note that in the present study a weighted CAL was used, measurements were only performed in standing, and raw measurements were used for all statistical analysis, which contrasts to the methods of Sweeney, O'Sullivan, Kelly (23). Even so, similar results were found between studies, which supports the use of a CAL to elicit LM contraction.

The calculations used in this study allowed for links to be made to hand dominance, which is highly important in sporting populations using asymmetrical limb movement. Hides, Gilmore, Stanton, & Bohlscheid measured R_{LM} in individuals with and without LBP and made measurements from L2 to L5 (10). The authors did not consider hand dominance, and calculated asymmetry as a percentage difference between the largest and smallest out of the left and right measurements. Therefore, unlike the completed study, results could show if there was asymmetry but not which side was larger and could not draw on links to hand dominance or symptomatic LBP side.

Hides, Stanton, McMahon, Sims, & Richardson performed a multilevel analysis of LM symmetry in elite cricketers with and without LBP and examined whether lumbar and core exercises reversed deficits in LM related to LBP (9). The study identified that elite players do have LM deficits despite their rigorous training programs, and that exercises did reverse deficits in LM symmetry. However, only R_{LM} was measured which provides no knowledge of LM contraction or activation in these individuals. The study also did not standardise for RTUI probe force, inclination and roll, whereas the present study which included such technology to standardise these parameters. Therefore, variation in force, inclination and roll was controlled, not allowing for image distortion or measurement bias to occur (12).

Investigating stability muscle symmetry in sportspeople has been suggested as highly important (7), especially considering that amateur cricketers do not partake in year-round training and have been identified as having a high injury risk (22). The asymmetrical nature of pace bowling has been linked with stability muscle asymmetry, which was suggested as a reason why pace bowlers have a largely unilateral distribution of injury (24, 19). While this study does not address injury in its results, it did investigate a predisposing factor to injury in this population – LM asymmetry. Ranson, Burnett, O'Sullivan, Batt, & Kerslake suggested that stability muscle asymmetry of the lumbar spine may be an inherent trait of the pace bowler due to the muscular loading patterns which occur throughout a delivery (19). The results of this study identified that amateur pace bowlers do not have the significant resting LM asymmetries previously reported in elites (9). Further research is required to determine whether this trend is found in other amateur cricketing populations so that the results may be generalisable among all amateur cricketers. Differences in strengthening and conditioning programs between elite and amateur bowlers should be investigated to determine if this is a contributing factor to the difference of findings between populations.

There were limitations to the completed study. The principal investigator was a novice examiner with limited RTUI training. However, through the use of the FPD and demonstration of near perfect intra-examiner reliability, measurement error was reduced. Also, this study did not specify limitations on time involved in specific activities, sport or occupation. Ranson, Burnett, O'Sullivan, Batt, & Kerslake suggested that such factors could affect stability muscle morphology (19). Therefore, such variations may have affected results obtained. Finally, the rationale behind the decision to use a weighted CAL was not made quantitatively. Future research should investigate a desirable contraction size as measured using RTUI.

Despite the results revealing a lack of significant differences, this was the first study to investigate stability muscle morphology in amateur cricket pace bowlers, who inadvertently make up the majority of the cricketing population in Australia. Thereby, the results provide a baseline understanding of stability muscle morphology in amateur cricket pace bowlers.

Establishing a baseline is important in determining a reference point for future research and the development of population appropriate and specific rehabilitation programs. Rehabilitation is an area which was not investigated in this study but should be an area of focus for future research. Further research would provide health professionals with important evidence-based principles to guide therapy in respect of this population. Thus, this study serves as a stepping stone for future research into amateur cricket pace bowlers, lower back injury, rehabilitation and injury prevention.

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