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Multifidus Muscle Size and Atrophy Among Dancers With and Without Low Back Pain

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ABSTRACT

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and Without Low Back Pain

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Design: A single-blinded, cross-sectional observational study.

Objectives: Examine muscle cross-sectional area and symmetry of the lumbar multifidus muscle in elite ballroom dancers with and without low back pain (LBP).

Background: The prevalence of LBP among elite ballroom dancers is high and at Brigham Young University is 57%. Previous research has linked lumbar multifidus muscle atrophy to low back pain; however this relationship has not been examined in ballroom dancers.

Methods and Measures: Lumbar multifidus cross-sectional area was assessed at rest on the right and left side at levels L1-L5. Thirty-seven subjects (age 24 ± 3.2 years; height, 172.8 ± 11.3 cm; mass, 54.6 ± 4.5 kg) were divided into one of three groups. Participants who reported LBP severe enough to interfere with dance training and daily living were allocated to the LBP group (reported pain at rest, during dance, and following dance) (n=15). Subjects who reported LBP that was not strong enough to interfere with training and daily living were allocated to the minimal pain group (reported pain during dance and following dance) (n= 6). And those who reported no back pain were put into the no pain group (n=16).

Results: There were no significant difference in demographics between the groups (P>0.05). There was no significant difference between groups in multifidus cross-sectional area (P = .437). Asymmetry was found in all groups with the left side being larger than the right (P < .002).

Conclusion: This study provides new information on lumbar multifidus cross-sectional area in elite ballroom dancers. Future research needs to examine other causes of LBP in elite ballroom dancers in an attempt to decrease LBP in these athletes.

Keywords: multifidus cross-sectional area, abdominal thickness, dance, chronic low back pain

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Introduction

Back pain is common among the general population and in athletes, despite their practice and training. Low back pain (LBP) is a musculoskeletal disorder that affects as many as ninety percent of Americans at some point in their lives and has affected approximately one-fourth of Americans within the last three months.[6] Since LBP is a leading cause of missed work days, and the leader in job related disability,[23] it is no surprise that each year Americans spend nearly $100 billion dollars trying to alleviate this pain.[3, 23] Among athletes an estimated 30% are affected by back pain[27] which may alter their training and participation in their respective sport. Elite ballroom dancers are among those who often suffer from LBP.[9] It is important to study potential causes for back pain in specialized athletes, such as elite ballroom dancers, in an effort to minimize the occurrence of back pain and its effect on training and performance.

Many studies show that LBP is directly related to multifidus muscle size.[7, 10, 13, 15, 24, 30] Multifidus size helps determine muscle strength when controlling for body size (height and mass).[30] Individuals with chronic back pain have shown greater amounts of muscle atrophy, so logically, the degree of muscle atrophy explains the extent of the pain and level of disability.[30] Researchers continue to examine the asymmetry of lumbar multifidus as a major contributor to LBP in an effort to find potential ways to alleviate this pain.[7, 13, 24, 28, 30] One of the most reliable measurements of multifidus cross-sectional area used in research today is ultrasound imaging.[1, 2, 15, 24] With refined techniques, ultrasound imaging is now considered as valid and reliable as magnetic resonance imaging in representing soft tissue of the multifidus muscle.[19]

Multifidus muscle size in elite ballroom dancers has not been previously investigated. Dancers are known for having a high prevalence of LBP;[5] but it is unclear if this is due to muscle atrophy or some other factor such as facet dysfunction, hypomobility, myofascial dysfunction, the nature of the movements the dancers perform or a combination of multiple factors. Intuitively it seems that dancers would have relatively strong back muscles compared to the normal population due to their rigorous workouts, practice and training involving back extension movements.

We wanted to investigate the relationship between LBP and lumbar multifidus muscle size in elite collegiate ballroom dancers. Thus, the two main purposes of this study were to determine: 1) if multifidus size differed between dancers with and without LBP, and 2) the relationship between back pain and lumbar multifidus muscle symmetry. We also investigated differences between genders. We hypothesized that non-injured dancers have a larger lumbar multifidus muscle than dancers with LBP. We theorized that ballroom dancers experiencing LBP would have asymmetry between right and left lumbar multifidus and atrophy on the painful side, while dancers without back pain do not, similar to findings of a study investigating cricket players.[13] Finally, we expected male dancers to have larger multifidus muscle size than female dancers after adjusting for body size as seen in previous research [22]. We additionally wanted to investigate the use of the rectus femoris and abdominal muscles size as a predictor of lumbar multifidus size instead of BMI or height and mass.

Methods

Participants

Thirty-seven elite collegiate ballroom dancers with and without LBP between 18 and 30 years of age were recruited for this study. To qualify for this study all subjects were required to be members on one of the top two Brigham Young University (BYU) ballroom dance teams; the touring team or back-up touring team. Subjects were asked to fill out a pre-participation low back pain questionnaire (Appendix A) to determine eligibility and to determine the nature of current symptoms and location of pain. Those who were pregnant or had not been dancing consistently over the last year were excluded from the study. This study was approved by the Institutional Review Board at Brigham Young University, Provo, Utah. Subjects who reported a history of LBP severe enough to interfere with dance training and daily living were allocated to the LBP group (reported pain at rest, during dance, and following dance). Subjects who reported LBP that was not strong enough to interfere with training and daily living were allocated to the minimal pain group (reported pain during dance and following dance). And those who reported no back pain were put into the no pain group similar to previous research.[13]

Procedures

Participants who agreed to participate signed an informed consent to ensure that their rights and information were protected. Participants were asked to fill out three visual analog scales (pain at rest, pain during dancing, and pain immediately following dance) and the Oswestry Disability Index. In order to assess and categorize individuals with and without back pain the visual analog scale is often used with the Oswestry disability index.[8, 13, 29] Research assistants were present to help subjects with questions.

Ultrasound Imaging

Cross-sectional areas of the dancers' lumbar multifidus (right and left L1 through L5) and abdominal muscles were recorded according to established protocols[13, 14, 21, 25, 26] with Doppler Ultrasound. The ultrasound imaging unit (GE Logic e; GE Healthcare, Wisconsin, USA) was equipped with a 4 to 5-MHz convex array transducer (4C probe) with a 6 cm footprint. This probe was used to get uniform depth and consistency in measurements between patients.[30] To measure multifidus muscle size, participants were positioned prone on an examination table with a pillow under their hips to minimize the lordotic curve (Hides et al., 2008).[13] Spinous processes L1 to L5 were palpated and anatomical landmarks (facet joints) were used for consistency of measurements.[13, 30] Electroconductive gel was applied and the transducer head was placed transversely over the spinous process of the vertebral level being measured.[13] Ultrasound images were captured from a 10 second video clip of the multifidus muscle contacting and returning to rest on the right and left side segmentally from L5 to L1 vertebral levels. To produce contraction of the multifidus participants were asked to extend their hip by lifting their leg off the table on the side being measured.[28] Bilateral images of the multifidus muscle at each lumbar spinal level were taken and cross sectional area of the multifidus muscle was measured by tracing the muscle border using internal software. The border of the inner edge of the muscle was traced when the muscle was at rest on each image for consistency throughout the study, as was found valid and reliable in previous research.[2, 28, 30] The average of two measurements bilaterally at each level was used for statistical analysis. Researchers who performed ultrasound imaging and measurements were blinded to subjects grouping.

Bilateral images of the abdominal muscles (transverse abdominis and internal oblique) were also taken. Thickness measurements were taken of both obliques and transverse abdominis muscles according to established protocols.[14, 21] In order to record abdominal muscle thickness, the participant was positioned supine on the examination table with a pillow under their knees. The ultrasound probe was placed on the abdomen, right and then left of the umbilicus. The rectus abdominis was identified, and then the probe was moved laterally to identify the linea semilunaris , allowing us to identify the junction of the transverse abdominis, internal oblique and external oblique. This insertion point was placed 2cm from the medial edge of the ultrasound image.[21] The participant was asked to draw his/her umbilicus to the table to produce contraction of the abdominal muscles. A video clip of the abdominal muscles from non-contracted state to contraction to relaxation was recorded. Measurements were taken when abdominal muscles returned to relaxation. All ultrasound images were coded, stored on the ultrasound unit's hard drive, and later recalled for measurements.

Reliability

Two-day intraexaminer reliability, indicating the repeatability of image measurements, was high ($ICC_{3,1}$ = 0.99 with a 95% confidence interval (CI): 0.993-0.998 $ICC_{3,K}$ = 0.99 CI: 0.997-0.999) and similar to previous authors.[16]

Statistical Analysis

Among the 37 ballroom dancers who participated in the study 16 reported no back pain, 6 reported minimal low back pain, and 15 reported LBP. No subjects dropped out of the study. A mixed model analysis of variance was initially used to test for similarity between groups in age, height, mass, BMI, years of dance training, and time spent each week in dance. A stepwise comparison was then conducted to determine if any interactions existed. The dependent variable in the analyses was the cross-sectional area of the multifidus muscle, L1 through L5 each analyzed separately. After the step-wise analysis, mass, side of lumbar spine and vertebral level were used as covariates.

Results

Thirty-seven elite ballroom dancers from the BYU tour or back up tour team participated in the study, all of which met our inclusion criteria, 16 reported no back pain, 6 reported minimal pain at times, and 15 reported LBP. Table 1 outlines the demographic characteristics of the participants in this study. There was no significant difference between groups based on height, mass, age, BMI, years of dance and time spent dancing each week ($P > .05$). Table 2 shows the pain visual analog scale and Oswestry Disability Index means and standard deviations for each group. There were significant differences in VAS pain and Oswestry Disability scores between groups (see table 2 for p-values).

Results of the step-wise regression showed no significant difference in lumbar multifidus size between those with and without LBP ($P = .437$). Table 3 shows the average multifidus muscle size at each vertebral level. There was a significant difference between vertebral levels ($P < .0001$). This result indicated an increase in muscle cross-sectional area when moving from L1 to L4 with no significant difference between levels L4 and L5 ($P > .05$).

Results of the step-wise regression showed a significant difference between right and left muscle cross-sectional area in all dancers ($P < .002$). The left lumbar multifidus was consistently bigger than the right by an average of .25 cm^2 (Table 4).

A gender difference between lumbar multifidus cross-sectional area was not seen ($P > .05$) after correcting for body size. Similarly, we found that the rectus femoris muscle cross-sectional area and abdominal thickness (transverse abdominis and internal oblique) were not related to multifidus cross-sectional area ($P > .05$). Mass was a better predictor of lumbar multifidus muscle size ($P <.0001$) than gender, height, and rectus femoris muscle size in ballroom dancers.

Discussion

Three investigations have explored the differences in multifidus muscle size in different athletic populations with LBP.[13, 18, 22] This is the first study to look at low back pain and lumbar multifidus size in elite ballroom dancers. The purposes of this study were to determine: if lumbar multifidus muscle size differed between elite ballroom dancers with and without LBP and the relationship between back pain and multifidus muscle symmetry. We also investigated gender differences between our dependent variables.

LBP in dancers was not related to lumbar multifidus muscle atrophy. Our data showed comparable multifidus cross-sectional areas between those with and without low back pain. These findings are in contrast with several studies of non-athletic populations [11, 12, 30] as well as an athletic cricket player population.[13] Our study investigated elite ballroom dancers that have specialized dance routines and training programs, which seemed to have influenced multifidus size regardless of the presence of back pain. Two other studies found that elite athletes with a history of chronic low back pain did not exhibit atrophy of the lumbar multifidus muscle and support our findings.[18, 22] McGregor et al. studied elite oarsman and found that rowers with low back pain actually had a larger lumbar multifidus muscle than those without pain. Sitilertpisan et al. investigated multifidus size in elite weightlifters, who, similar to dancers, have a frequent incidence of low back pain. He found no significant differences between groups (LBP and healthy group) and suggested that some athletic populations may have competing influences of pain and high physical demands in performance and training.[11, 18, 22] This could be true in ballroom dancers who perform unusual movements regardless of pain, and who practice many hours a week and attend specialized dance instruction classes. In these classes, focused effort is given to "engaging the core muscles" by actively contracting abdominal and back muscles while performing the dance moves. This "engaging the core" may provide a stimulus that helps maintain multifidus muscle size. It appears that some athletic populations (weightlifters, rowers and ballroom dancers) behave differently regarding multifidus symmetry and low back pain compared to the general population, possibly due to specialized movements and specific training effects.

A significant difference was found between right and left multifidus muscle size. The left side was consistently bigger than the right side by an average of .25 cm^2. This difference was not group specific. This could be related to posture during dancing or routines requiring specific movements. This finding was not seen in the studies investigating multifidus size in weightlifters, cricket players or rowers.[13, 18, 22] This suggests that there is some aspect of dance that contributes to side asymmetry likely due to the side-specific movements and dance routines required to compete at an elite level. For instance, a dance couple faces each other and both dancers rotate their trunk to the right in order to assume the correct dance position. Contraction of the left lumbar multifidus will help facilitate this rotation to the right, thus resulting in an increased asymmetric training stimulus on the left side of the lumbar spine. Another reason for not finding a group-specific difference in multifidus size could be the equal amount of hours spent in dance each week between those with and without back pain. Both groups spent an average of 17 hours a week dancing. Dancers continued to work through their pain and did not give their muscles a chance to atrophy from disuse. Thus, some aspects of dance may have resulted in an asymmetric training stimulus for the lumbar multifidus. This may be true, particularly due to the emphasis on "engaging the core" muscles as routinely coached by dance instructors. Dancers with back pain reported the pain lasting greater than 3 months, which is often seen as a criterion for chronic low back pain.[30] Another possibility is that the pain may not be great enough to require them to modify movements to avoid pain which may lead to the muscular changes over time seen in other populations of individuals with chronic LBP. The dancers in this study may have overestimated their pain, which one might consider insufficient to elicit a change in movement and thus the atrophy of the multifidus due to inhibition seen in previous research.[13] However, individuals in the pain group reported a resting VAS of 2.4 and a VAS after dance of 4.6, which is in line with reported pain levels in a previous study (Hides et al. reported a vas of 4.3 ± 3.0 in the LBP group)[13] and was found to be statistically different than the no pain group. The VAS scores for the pain group were at least 2 cm greater than the no pain group; the difference of 2 cm has been report as a clinically significant difference in VAS reported pain levels.[4, 20] The pain group had a relatively low Oswestry Disability Index score indicating that despite the pain they were experiencing they maintained a high level of overall function, which they need to be able to compete at elite levels of dance.

We theorized that the rectus femoris muscle size would be a better predictor of lumbar multifidus muscle size than height, mass, or BMI. However this was not the case. We found that in elite ballroom dancers mass was the best predictor of multifidus muscle size. For every kilogram increase in mass there was a .05 cm^2 increase in area. BMI and height were not significant when the person's mass was considered. This could be because of the similarity of body types between genders' within this population and may not hold true for other populations. Elite dancers are very similar in body size and body composition; primarily, they are very slender and athletic individuals. Very small differences were seen between all participants' BMI and height with a mean and standard deviation of 21.2 ± 0.3 and 1.75 ±0.02 kg respectively. Since participants had similar body types the variation in mass could be due to increased whole body muscle mass which would be account for increases in multifidus size with increased mass.

We examined the transverse abdominis and internal oblique muscle thickness and found that elite ballroom female dancers had slightly smaller transverse abdominis and larger internal oblique compared to averages reported by Mannion et al. in a normal population.[17] Male ballroom dancers had similar transverse abdominis muscles and much larger internal obliques compared to averages reported by Mannion et al.[17] Males had larger abdominal muscles than females similar to the relationship seen in Mannion et al.'s study. There was no significant relationship between abdominal musculature size and multifidus muscle size. Table 4 shows the average transverse abdominis and internal oblique muscle size as well as average muscle size reported by Mannion et al.[17] Right and left sides had comparable abdominal muscle thickness (Table 4). Dancers need coordinated control of their core musculature to perform at high levels, without which they would not be able to continue to excel in dance. These dancers are taught to engage their core throughout dancing, thus are routinely preforming core strengthening exercises. The increased internal oblique muscle thickness could be due to activation of the internal oblique during dance, targeting this core stabilizer. Further research needs to be done to better understand reasons for internal oblique hypertrophy.

Further research should be undertaken to determine contributors to LBP in elite dancers. Additional research could assist dancers, coaches, athletic trainers and physical therapists in lessening the incidence and detrimental effects incurred by dancers suffering LBP. This study indicates, along with others,[18, 22] that LBP in athletic populations is not always connected to multifidus muscle size or asymmetry.   Our study is limited to our population of elite dancers at Brigham Young University 18 to 30 years of age. We limited participants to the top dancers at BYU in order to have a sufficient amount of dance experience to represent characteristics of elite ballroom dancers. Our results may not be applicable to all dance genres. Other dance styles with different movement patterns may affect the lumbar multifidus differently than ballroom dance.

Conclusion

Elite ballroom dancers with low back pain did not exhibit any significant atrophy in lumbar multifidus muscle cross-sectional area compared to those without LBP. While no differences were seen between genders, there was a significant difference between right and left muscle size, with the left side being larger. The only covariant significantly related to multifidus muscle size was mass. 57% of elite ballroom dancers had chronic LBP. These results suggest that further investigation is needed to determine other possible sources of back pain which could be addressed to help decrease the prevalence of LBP in elite ballroom dancers.

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Table 1. Demographic Characteristic of Participants

Variables	Mean ± SD
Age	22.97 ± 0.35
Height	1.75 ± 0.02
Mass	65.17 ± 1.76
BMI	21.2 ± 0.30
Hours of practice per week	17.12 ± 0.96
Years of dance training	9.16 ± 0.72

Table 2. Pain VAS and Oswestry Disability Index Scores

Group	Pain at Rest	Pain During Dance	Pain Following Dance	Oswestry Disability Index
No Pain (n = 16)	0.20 ± 0.38	1.17 ± 1.11	0.83 ± 0.63	1.19 ± 1.80
Minimal Pain (n = 6)	0.48 ± 0.55	2.83 ± 2.04	2.83 ± 2.15*	1.67 ± 1.37
Low Back Pain (n = 15)	2.39 ± 1.79*†	4.16 ± 2.08*	4.56 ± 1.96*	5.87 ± 3.16*†

* Significant different from the no pain group (*P* <0.03).

† Significantly different from the minimal pain group (*P* <0.05)

Table 3. Average Multifidus Muscle Size at each Vertebral Level

Vertebral Level	Right CSA (cm^2)	Left CSA (cm^2)
L1	2.28 ± 0.10	2.39 ± 0.10
L2	3.23 ± 0.14	3.29 ± 0.13
L3	4.85 ± 0.22	5.02 ± 0.22
L4	7.37 ± 0.24	7.68 ± 0.24
L5	7.65 ± 0.20	7.89 ± 0.21

Table 4. Abdomial Muscle Size of Dancers Compared to Normal Population

	Male		Female		Male (Mannion)		Female (Mannion)	
	Right	Left	Right	Left	Right	Left	Right	Left
Transverse Abdominis	.41 ± .02	.42 ± .03	.33 ± .02	.31 ± .02	.39 ± .09	.40 ± .10	.37 ± .10	.36 ± .10
Internal Oblique	1.01 ± .07	1.05 ± .09	.79 ± .05	.79 ± .04	.86 ± .24	.83 ± .24	.73 ± .24	.67 ± .21

Figure 1. Right L5 Lumbar Multifidus

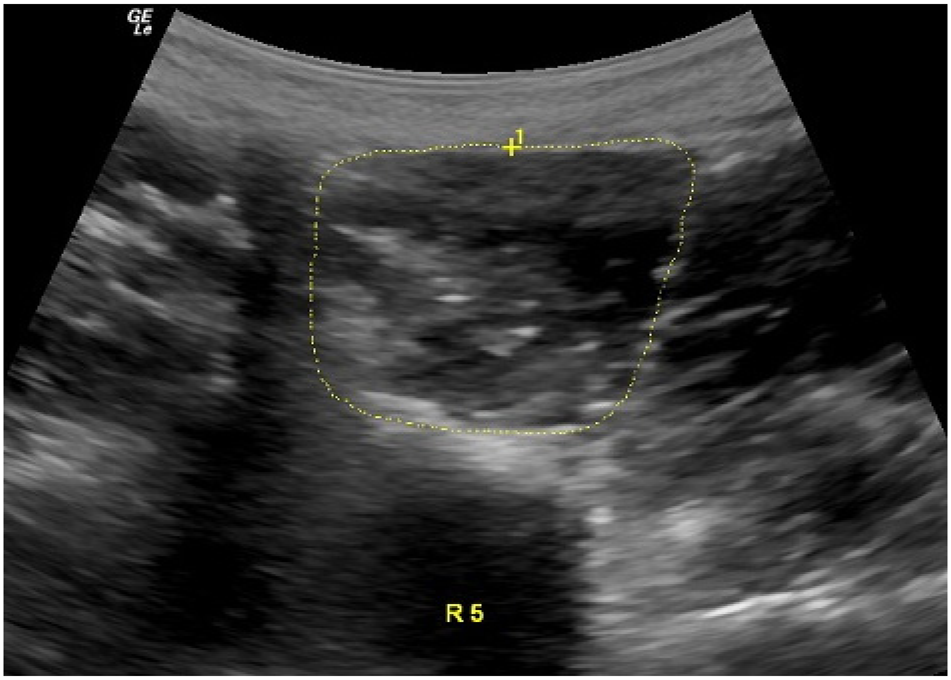
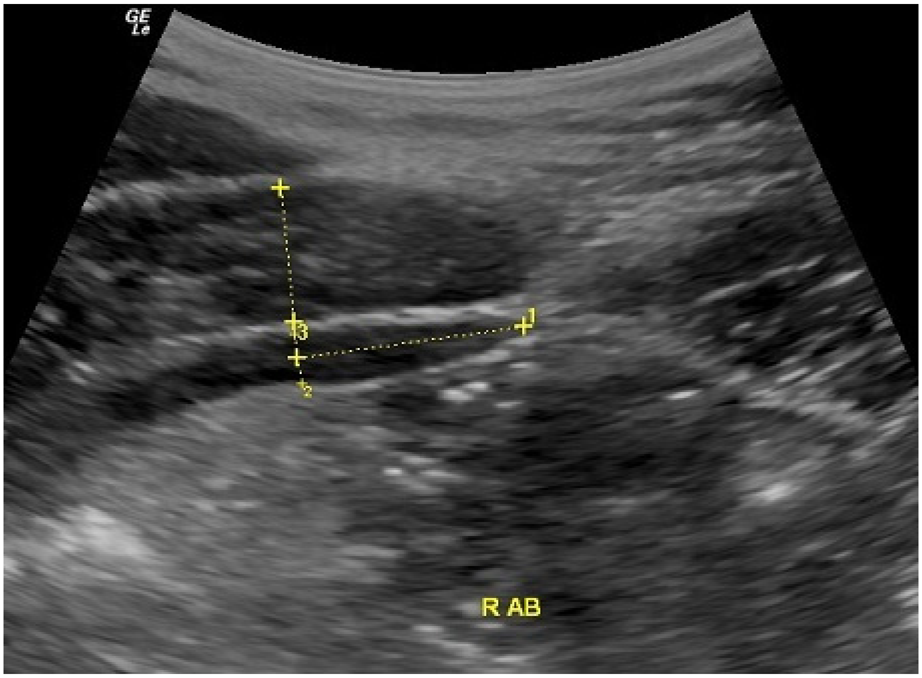


Figure 2. Right Abdominal Muscles



Appendix A

Subject #:

Name:

Age:

Height:

Weight:

Gender: M F

Are you currently pregnant?

Have you ever had surgery on your back?

Dance Team: Tour Team Back-up Tour Team

Years of dance training:

Type of dance: Standard (including smooth) Latin Other

Hours each week spent in dance: Standard____ Latin____ Other____

Other sports/activities you participate in:

Do you have back pain?

How long have you been experiencing back pain?

Reason for back pain?

Please mark with an X location(s) of back pain on image: