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Original Research Paper

Radiology

THE RELATIONSHIP BETWEEN QUADRATUS LUMBORUM MUSCLE STIFFNESS AND PAIN SEVERITY IN CHRONIC LOW BACK PAIN: A SHEAR-WAVE ELASTOGRAPHY STUDY.

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ABSTRACT

Background: Chronic low back pain (CLBP) is a common musculoskeletal condition that can cause significant morbidity and functional disability. Decreased stiffness and impaired mechanics of trunk muscles have been hypothesized as potential mechanisms that may perpetuate pain. Shear-wave elastography (SWE) is an ultrasound technique that can quantify tissue stiffness non-invasively; however, the association between SWE and clinical variables in CLBP patients has yet to be characterized. **Aim:** Quantify stiffness of the quadratus lumborum (QL) muscle using ultrasound shear-wave elastography (SWE) in patients with CLBP and determine its relationship to pain intensity, functional disability, and pain chronicity. **Study Design:** Cross-sectional observational study. **Methods:** A total of 60 adults with CLBP of greater than 12 weeks duration underwent bilateral QL muscle stiffness measurements using ultrasound SWE, with shear wave speed (SWS, m/s) and Young's modulus (kPa) obtained. Participants also completed subjective measures of pain (Visual Analog Scale [VAS]) and disability (Oswestry Disability Index [ODI]). Pearson's or Spearman's correlation coefficient were calculated between QL stiffness measures and pain intensity, disability, and pain duration. A p value of less than 0.05 was considered significant. **Results:** Mean age of participants was 28.4 ± 10.9 years and gender was evenly distributed. Mean bilateral QL stiffness was 2.43 ± 0.60 m/s (Young's modulus: 18.7 ± 8.8 kPa) and there was no significant difference between sides ($p > 0.05$). Mean VAS score was 4.8 ± 1.5 and mean ODI score was 12.0 ± 6.8. There was a significant moderate negative correlation between bilateral QL stiffness and pain intensity ($r = -0.50$, $p < 0.001$), meaning that as stiffness decreased pain intensity tended to increase. No significant correlations were found between QL stiffness and disability ($r = -0.12$, $p = 0.35$) or pain duration ($r = 0.06$, $p = 0.64$). **Conclusion:** Ultrasound elastography measurements of QL muscle stiffness in patients with CLBP was symmetric between sides and significantly correlated with pain intensity but not disability or chronicity. Ultrasound elastography may be useful for quantifying pain intensity in patients with CLBP as stiffness of the QL muscle decreased with increasing pain severity. Future prospective studies are needed to further assess causality and clinical utility of QL stiffness as a pain monitoring tool.

KEYWORDS : Chronic Low Back Pain; Quadratus Lumborum; Shear-Wave Elastography; Muscle Stiffness; Visual Analog Scale; Oswestry Disability Index.

INTRODUCTION

Low back pain (LBP) is a prevalent musculoskeletal condition and leading contributor to activity limitation within clinical settings. Descriptions of LBP as a biopsychosocially complex and heterogeneous condition have provided a framework for understanding broad ranges in pain persistence and functional disability [1]. Meta-analytic estimates of LBP prevalence confirm a substantial proportion of adults are affected worldwide [2], and like other common pain conditions, incurs healthcare resource use and lost productivity, manifesting prominently as disability [3]. Prioritizing efforts to prevent progression to chronic back pain (CBP) is important given associated impairment; prospective studies originating in primary-care have identified acute pain features associated with persistence or transition to chronicity, highlighting opportunity for improved phenotyping and objective characterization of people with chronic presentations [4].

Year epidemiologic reviews support that LBP is a leading contributor to years lived with disability on a global scale, driving loss of productive capacity [3]. Prevalence data similarly suggests many individuals presenting with LBP are classified under non-specific diagnostic categories, for which routine imaging may fail to elucidate structural cause of pain or functional deficit [2]. The complex biopsychosocial nature of CBP further supports investigation of measurable and modifiable patient characteristics associated with pain experience, disability, and quality of life [1,4].

The lumbar spine/trunk musculature has received increasing consideration as a potential contributor to persistent symptoms and functional impairment. The quadratus lumborum (QL) is uniquely situated to affect lumbopelvic stability and lumbar kinematics, and preliminary anatomical/biomechanical studies have laid the foundation for relevance to mechanical load and control of trunk movement [5]. Symptom-specific discussions have also positioned the QL within the clinical LBP narrative, prompting investigation of QL impairment as part of the clinical characterization of CBP [6].

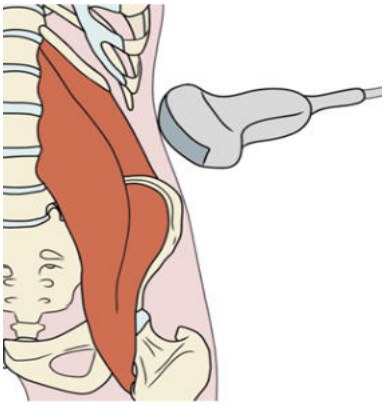
Identifying reliable methods of assessment is essential for translation into clinical practice. Assessment of myofascial trigger points via palpation is common in clinical practice; however, recent evidence syntheses have called into question the reliability of physical examination to support diagnosis of trigger-points given broad inconsistency across examiners

[7]. Advances in imaging assessment have extended beyond morphology to "quality" indices; magnetic resonance imaging-based assessment of the paraspinal muscles has quantified parameters such as cross-sectional area, functional cross-sectional area and fat infiltration and related these to duration of CBP and health-related quality of life [8]. Investigation of paraspinal muscle mechanical properties has similarly progressed, with increasing attention to stiffness as an objective metric that may reflect features of muscle status not captured by size metrics alone.

In observational contexts, lumbar muscle stiffness has been shown to differ between individuals with and without LBP and may relate to pain intensity and disability, providing preliminary support for clinical relevance [9]. Ultrasound assessment of paraspinal muscles has similarly quantified stiffness and related findings to muscle size and sagittal alignment parameters, demonstrating feasibility of muscle stiffness assessment in working-age adults [10]. Other methods have also been applied to assess lumbar muscle tone and stiffness, with myotonometry used to quantify and report reproducible measures of these parameters among young adults with CBP [11,12]. Critically, methods of regional specificity have been examined for the QL, with recent ultrasound shear-wave elastography protocols validated for measurement reliability [13].

While these preliminary data are promising, literature remains limited and inconclusive. A systematic review with meta-analysis published earlier this year determined that variability in findings across trunk muscles, measurement approaches, and patient positions during stiffness measurement limit confidence in this body of literature and constrain generalizability [12]. Interventional research is also mixed, with exercise-based interventions shown to impact lumbar muscle stiffness values but less is known about how these changes relate to meaningful clinical improvement [14]. Further observational work related to the biopsychosocial features of CBP is needed, and may benefit from improved consistency in assessment approaches and selection of clinically relevant outcomes.

The QL is understudied in chronic back pain populations, and our group recently reported preliminary relationships between age-related decreases in stiffness and disability in young adults [15]. There remains a clear gap in data regarding the relationship between QL stiffness and patient-centered features of CBP when measured with standardized assessment protocols. CBP is frequently encountered within outpatient and occupational settings in India, creating objective measures of trunk muscle status may improve risk-stratification beyond symptomatic reports. Given the high prevalence and disability associated with LBP worldwide [2–4], poor reliability of palpation in clinical settings [7], and preliminary evidence suggesting QL stiffness is associated with CBP [15], our study will investigate the relationship between stiffness of the QL muscle and clinical features of CBP to improve phenotyping of this commonly encountered condition in India.



METHODOLOGY

Study Design

This was a cross-sectional observational study conducted to evaluate the association between quadratus lumborum (QL) muscle stiffness and clinical features of chronic low back pain.

Study Setting

The study was conducted in the Department of Radio Diagnosis, Sri Devaraj Urs Medical College, Tamaka, Kolar. Eligible participants presenting during the study period and fulfilling the selection criteria were enrolled after obtaining written informed consent.

Sample Size Estimation

Final sample size was N = 60. Sample size estimates for this correlation based study evaluating QL stiffness with features of chronic back pain were calculated using Fisher's z-transformation for correlation using two-sided $\alpha = 0.05$ with 80% power ($Z_{1-\alpha/2} = 1.96$ and $Z_{1-\beta} = 0.842$). With n = 60 participants, the study had power to detect a lower bound correlation of approximately $r \approx 0.36$ between stiffness and selected clinical outcome measures. Sixty participants were recruited.

Participant Selection

Recruitment was based on consecutive sampling of available participants who fulfilled inclusion criteria. Adults between 18–60 years of age with chronic low back pain defined as pain localized to the buttock, posterior thigh, or posterior leg radiating from below the lower costal margin and above the knee that had been present for greater than 12 weeks. Subjects who understood the nature of the study and capable of providing written informed consent were enrolled if they agreed to receive an ultrasound evaluation of the QL muscles. Individuals were excluded if they had acute spinal injury or recent spine surgery, any signs or symptoms of neurological deficit suggestive of radiculopathy or myelopathy, spinal deformity such as scoliosis or kyphosis, inflammatory conditions affecting the spine, or unable to safely complete imaging procedure or study protocol.

Materials and Instruments

Evaluations were conducted using an ultrasound machine with shear-wave elastography (SWE) imaging capability, and a linear or deep imaging curvilinear transducer. Participants rated their pain severity with a Visual Analog Scale (VAS; 0–10). Function was determined through Oswestry Disability Index (ODI) questionnaire. Posture was standardized with the use of cushions/support pads. Information was recorded with caserecord forms specifically designed for this study or encrypted digital record software.

Study Procedure

After eligibility confirmation, procedures were explained and written informed consent was obtained from each subject. Participants lay prone on the examination table with a pillow placed underneath the abdomen, minimizing lumbar lordosis allowing for standard positioning during imaging of the QL muscle. B-mode ultrasound allowed for localization of the bilateral QL and standardized image settings. SWE was performed over the mid belly of the QL bilaterally while avoiding placement over fascia or other non-muscular tissue. Three stiffness measurements (kPa) were recorded bilaterally and averaged for statistical analysis as representative of QL stiffness. Following ultrasound imaging, subjects were clinically assessed. Pain severity was documented using VAS and disability using ODI. To limit inter-operator error, all ultrasound imaging and measures were completed by a single trained research practitioner. Elastography values and clinical scores were inputted into a prepared data sheet within a day of data collection.

Statistical Analysis

Data were entered into Microsoft Excel spreadsheets and

analyzed using SPSS software version 22 (IBM Corp., Armonk, New York). Continuous variables were expressed as mean ± SD (or median and interquartile range when appropriate), and categorical variables were described as frequencies (%). Pearson's correlation coefficient and Spearman's rank correlation coefficients were used to assess the associations between QL stiffness with features of chronic back pain (VAS and ODI scores), as appropriate. P-values < 0.05 were considered statistically significant (2-tailed).

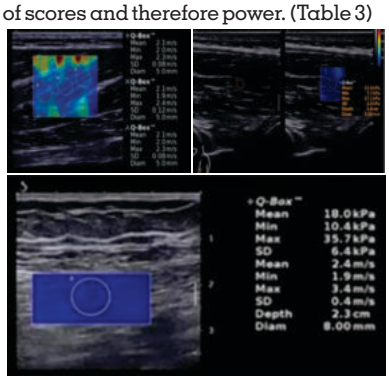
RESULT

This was a cross-sectional observational study conducted to evaluate the association between quadratus lumborum (QL) muscle stiffness and clinical features of chronic low back pain.

Sixty CLBP subjects participated in the study. The average age was 28.4 ± 10.9 years, which means that most participants were adults. The sample consisted of equal parts male and female subjects (male, 50%; female, 50%), which reduces sex-associated sampling bias and allows for equal consideration of results between sexes regarding stiffness metrics. The mean BMI was 25.4 ± 4.6 kg·m−2 which falls into the overweight classification by WHO standards. Overall, 51.7% of participants were considered overweight (n = 21, 35.0%) or obese (n = 12, 16.7%), showing that overweight BMI classifications are common in CLBP patients and could potentially alter the biomechanical loading of the lumbar spine and surrounding paraspinal musculature. The mean duration of pain was 62.0 ± 48.0 months. Since all patients suffered from CLBP, we can confirm that this was a chronic pain population with a wide range of pain chronicity. The average visual analog scale (VAS) was 4.8 ± 1.5. By VAS grading standards, this means that patients experienced moderate levels of pain. 56.7% of participants rated their pain as moderate and 20.0% rated their pain as severe. The mean Oswestry disability index (ODI) score was 12.0 ± 6.8. By ODI grading standards, this means that the average participant fell into the minimal disability category due to their low back pain. Breaking this down further, 76.7% of participants fell into the minimal disability category and 23.3% fell into the moderate disability category. There were no participants who fell into the grades of severe disability or higher. This shows that despite participants experiencing moderate pain, it did not appear to alter their function to a severe degree for the majority of subjects (Table 1).

Mean SWSs were 2.40 ± 0.64 m/s (right side) and 2.45 ± 0.56 m/s (left side) (mean bilateral = 2.43 ± 0.60 m/s) (Table 2). The mean Young's modulus values were 18.2 ± 8.7 kPa (right side), 19.1 ± 9.0 kPa (left side), and 18.7 ± 8.8 kPa (mean bilateral). There was no significant side-to-side difference between the Young's modulus values (p > 0.05). Therefore, there is no lateral dominance of stiffness characteristics in the QL muscles of this CLBP population. Also, the mean side-to-side difference of stiffness was trivial (−0.05 ± 0.34 m/s). The standard deviations of stiffness measures were moderate, suggesting variability between subjects in QL muscle stiffness. Overall, these data support our first aim to measure and describe the stiffness of QL muscles in CLBP patients using ultrasound shear-wave elastography.

Mean bilateral QL stiffness (QL SWS) correlated significantly with mean pain intensity (VAS) with a moderate negative correlation coefficient (r = −0.50, p < 0.001), indicating lower values of QL stiffness were associated with more severe pain ratings. This correlation magnitude can be interpreted as clinically important between muscle mechanical characteristics and pain intensity. Mean QL stiffness did not correlate significantly with mean functional disability (ODI) with a weak correlation coefficient (r = −0.12, p = 0.35) nor was QL stiffness associated with pain duration (r = 0.06, p = 0.64). These results show an association between QL stiffness and pain intensity instead of disability or chronicity. This was not seen with ODI which may have been secondary to low levels of disability seen in this sample causing decreased variability of scores and therefore power. (Table 3)



DISCUSSION

The average age of our patients with chronic low back pain was 28.4 ± 10.9 years, showing that our sample consists mostly of young adults. López-Redondo et al. (2025) also found that their cohort with chronic LBP was mainly composed of young individuals (female mean age 30.8 ± 13.7 years; male mean age 26.1 ± 8.6 years) [16]. However, there were no differences between sexes regarding age (p>0.05).Similarly, in their diagnostic accuracy study, López-Redondo et al. (2025) observed a mean age of 27.5 ± 9.6 years among chronic non-specific LBP cases (controls: 29.7 ± 13.1 years) [17]. In contrast, Tornblom et al. (2024) studied an older chronic LBP sample with mean age 45.16 ± 10.66 years [19], and Liu et al. (2025) reported mean age 41.43 ± 10.54 years in chronic LBP patients (controls: 40.82 ± 12.70 years) [18]. Overall, our age distribution aligns closely with the QL SWE studies in chronic LBP [16,17], while differences from other cohorts likely reflect varying recruitment settings, eligibility criteria, and target populations (young adult vs middle-aged chronic pain cohorts) [18,19].

In our study, the sex distribution was equal (50% males, 50% females). In our opinion, while López-Redondo et al. described a nearly even sex distribution in their chronic LBP observational cohort (37 women/39 men) [16], they noted 56.5% women among their cases in their diagnostic accuracy study [17]. Koppenhaver et al. reported 40% women in the LBP group (compared to 57% women in asymptomatic controls) [20]. Our findings are generally consistent with previous research showing that chronic LBP cohorts often include both males and females with relatively small differences in the proportion of women likely based on study setting and recruitment strategy [16,17,20]. This may be due to factors such as occupational mix (i.e., workforce cohorts), referral bias, and variation in threshold for inclusion based on disability or symptom severity.

In our study, mean BMI was 25.4 ± 4.6 kg/m^2, and 51.7% were overweight/obese (35.0% overweight; 16.7% obese), suggesting a clinically relevant burden of excess weight. López-Redondo et al. (2025) reported BMI values in a similar range (females 24.8 ± 5.7, males 26.5 ± 2.7 kg/m^2; p>0.05) [16]. In the diagnostic accuracy cohort, López-Redondo et al. (2025) reported BMI 23.2 ± 4.3 kg/m^2 in LBP cases (controls: 24.8 ± 4.9 kg/m^2) [17]. Tornblom et al. (2024) reported BMI 26.08 kg/m^2 in chronic LBP participants undergoing exercise intervention [19], and Liu et al. (2025) reported BMI 23.70 ± 3.08 kg/m^2 among chronic LBP patients [18]. Koppenhaver et al. (2019) similarly found higher BMI in the LBP group (26.1 ± 3.3) than controls (24.7 ± 2.4 kg/m^2) [20]. Our BMI profile is in concordance with studies reporting overweight-range BMI among chronic LBP cohorts [19,20], while lower BMI in some samples may relate to demographic differences and recruitment of less overweight populations [17,18]. Excess weight could plausibly contribute to altered trunk muscle loading and chronicity of symptoms, thereby influencing muscle mechanical behavior assessed by elastography.

In our study, pain duration averaged 62.0 ± 48.0 months, confirming long-standing chronic pain. López-Redondo et al. (2025) reported similar chronicity (females 65.8 ± 50.0 months, males 58.9 ± 46.3 months; p>0.05) [16], and their diagnostic accuracy study reported chronicity 63.8 ± 53.6 months in LBP cases [17]. Tornblom et al. (2024) reported LBP duration 73.52 ± 82.81 months [19], while Liu et al. (2025) reported longer symptom duration expressed in years (9.81 ± 8.61 years) [18]. Masaki et al. (2017) also observed long-standing symptoms, with LBP duration 98.0 ± 73.1 months in their LBP group [21]. Our findings are consistent with QL SWE-based chronic LBP cohorts showing chronicity around ~5 years [16,17], and differences versus longer-duration cohorts may reflect clinic population differences and chronic pain definitions (months vs years), as well as inclusion of more persistent or occupationally exposed subgroups [18,21].

In our study, mean VAS was 4.8 ± 1.5, with 56.7% reporting moderate pain and 20.0% severe pain. López-Redondo et al. (2025) reported similar pain intensity (females 4.9 ± 1.5, males 4.7 ± 1.4 on VAS; p>0.05) [16], and their diagnostic accuracy study reported VAS 5.0 ± 1.6 in chronic LBP cases [17]. Liu et al. (2025) reported mean pain intensity 4.00 ± 1.47 in chronic LBP patients [18], indicating slightly lower average pain than our cohort. Overall, our VAS results align closely with QL SWE studies in chronic non-specific LBP [16,17]. Small differences across cohorts may be due to variation in recruitment thresholds (moderate-to-severe vs broader chronic LBP), psychosocial context, and healthcare-seeking behavior influencing reported pain severity [18].

ODI did not demonstrate overwhelming disability in our cohort, as our mean was 12.0 ± 6.8 with 76.7% categorized as minimal disability and 23.3% moderate disability. Despite chronicity of pain, these data suggest most patients in our study had prolonged pain with maintained function. Interestingly, López-Redondo et al. (2025) demonstrated similar ODI values to our cohort (female 13.4 ± 7.1, male 9.0 ± 4.9) with significantly greater disability in females (p=0.003) [16]. In their diagnostic accuracy study cohort, they found ODI 12.7 ± 7.5 in LBP positive individuals [17], again similarly high as our mean ODI score. However, Tornblom et al. (2024) showed a notably higher baseline ODI of 29.40 in their intervention cohort [19]. This difference is in agreement with QL SWE cohorts demonstrating relatively low-to-mild disability despite chronic symptomology [16,17], while cohorts with increased disability likely recruited more functionally limited patients, or patients with moderate-to-severe LBP aimed for rehabilitation [19]. This may contribute to differences in stiffness–symptom relationship if disability alters muscle activation strategies and resting muscle mechanical properties.

We found mean QL stiffness measurements obtained with shear-wave elastography technique to be 2.40 ± 0.64 m/s (right), 2.45 ± 0.56 m/s (left), 2.43 ± 0.60 m/s (bilateral) for mean SWS and 18.7 ± 8.8 kPa for bilateral Young's modulus. We did not find a statistically significant difference between sides (p > 0.05) and the mean difference was trivial (−0.05 ± 0.34 m/s). In agreement with our finding of symmetrical stiffness bilaterally in chronic LBP patients, López-Redondo et al. (2025) conducted a diagnostic-accuracy case–control study comparing 40 participants with chronic non-specific LBP to 40 controls and found QL stiffness measurements to be 2.40 ± 0.60 m/s (mean SWS), 2.38 ± 0.66 m/s (right), and 2.43 ± 0.53 m/s (left) with no statistically significant difference between sides (SWS p = 0.715; YM p = 0.339) [17]. In another observational study examining people with low back pain, López-Redondo et al. (2025) reported QL stiffness values that were also in similar ranges (female: 2.41 ± 0.65 m/s, male: 2.47 ± 0.54 m/s) with no significant difference between sexes (p > 0.05) [16]. Taken together, our results are consistent with these QL-specific SWE studies showing bilateral symmetry and similar mean stiffness values in people with chronic LBP [16,17]. Given these similar findings across investigations, we suggest that in chronic non-specific LBP, changes to QL stiffness (if they exist) are likely attributable to system-level or bilateral neuromuscular changes as opposed to a unilateral mechanistic abnormality.

CONCLUSION

In the current study we found ultrasound shear-wave elastography measures of QL stiffness in chronic LBP were symmetrical and similar bilaterally, indicating the reproducibility of this assessment technique in chronic non-specific LBP populations. We also found mean values of QL stiffness similar to those found in other QL specific elastography studies, lending support to our technique. Previous work identified a moderate negative correlation between stiffness bilaterally and pain intensity. Pain intensity was negatively correlated with stiffness indicating lower stiffness was related to higher pain scores, while stiffness was not correlated with disability (ODI) or pain duration.

This is one of the first studies to utilize ultrasound shear-wave elastography as a means to objectively measure muscle properties in chronic low back pain. Results of our study may support stiffness being a quantitative marker for pain and potentially a target for monitoring and intervention in those with CLBP. Limitations of this study include its cross-sectional nature and therefore inability to assess causality. Longitudinal investigations are needed to see if changes in stiffness occur before changes in pain or as a result of certain interventions.

Table 1. Baseline Demographic and Clinical Characteristics of Participants with Chronic Low Back Pain (N = 60)

Variable	Overall (N = 60)
Age (years), mean ± SD	28.4 ± 10.9
Sex, n (%)	
Male	30 (50.0)
Female	30 (50.0)
BMI (kg/m²), mean ± SD	25.4 ± 4.6
BMI category (WHO), n (%)	
Underweight (<18.5)	3 (5.0)
Normal (18.5–24.9)	26 (43.3)
Overweight (25.0–29.9)	21 (35.0)
Obese (≥30.0)	10 (16.7)
Pain duration (months), mean ± SD	62.0 ± 48.0
Pain intensity (VAS 0–10), mean ± SD	4.8 ± 1.5
Pain severity (VAS), n (%)	
Mild (1–3)	14 (23.3)
Moderate (4–6)	34 (56.7)
Severe (7–10)	12 (20.0)
Disability (ODI 0–100), mean ± SD	12.0 ± 6.8
Disability category (ODI), n (%)	
Minimal (0–20)	46 (76.7)
Moderate (21–40)	14 (23.3)
Severe (41–60)	0 (0.0)
Crippled (61–80)	0 (0.0)
Bed-bound (81–100)	0 (0.0)

Table 2. Quadratus Lumborum Stiffness on Shear-wave Elastography (N = 60)

SWE stiffness measure	Right QL (Mean ± SD)	Left QL (Mean ± SD)	Mean bilateral (Mean ± SD)	p-value *
Shear Wave Speed (m/s)	2.40 ± 0.64	2.45 ± 0.56	2.43 ± 0.60	0.61
Young's Modulus (kPa)	18.2 ± 8.7	19.1 ± 9.0	18.7 ± 8.8	0.49
Side-to-side Difference (Right–Left)	−0.05 ± 0.34	—	—	—

Table 3. Association Between QL Stiffness and Chronic Back Pain Features (N = 60)

Predictor (Primary SWE Variable)	Outcome Variable	Correlation Coefficient (r/ρ)	p-value
Mean Bilateral QL SWS (m/s)	VAS (0–10)	−0.50	<0.001
Mean Bilateral QL SWS (m/s)	ODI (0–100)	−0.12	0.35
Mean Bilateral QL SWS (m/s)	Pain Duration (Months)	0.06	0.64

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