Published in final edited form as:

Arch Phys Med Rehabil. 2017 January ; 98(1): 51–57. doi:10.1016/j.apmr.2016.07.027.

Multifidi Muscle Characteristics and Physical Function among Older Adults with and without Chronic Low Back Pain

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Abstract

Objective—The purpose of this study was to determine if multifidi size and/or intramuscular fat were associated with self-reported and performance-based physical function in older adults with and without chronic LBP.

Design—Case-control study

Setting—Individuals participated in a standardized evaluation in a clinical laboratory and underwent magnetic resonance imaging (MRI) of the lumbar spine at a nearby facility.

Patient Sample—A volunteer sample of 106 community-dwelling older adults, aged 60-85 years, with (n=57) and without (n=49) chronic LBP were included in this secondary data analysis.

Intervention—Average right-left, L5 multifidi relative, i.e. total, cross-sectional area (rCSA); muscle-fat infiltration index (MFI), i.e. a measure of intramuscular fat; and relative muscle cross-sectional area (rmCSA), i.e. total CSA minus intramuscular fat CSA, were determined from MRIs. Linear regression modeling was performed with physical function measures as the dependent variables. Age, sex, and body mass index were entered as covariates. The main effects of L5 multifidi MFI and rmCSA, as well as their interaction with group assignment, were compared as independent variables.

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Presentation: Poster Presentation at the International Conference on Frailty & Sarcopenia Research: Boston, MA: 4/23/15.

Conflicts of Interest: Activities for Dr. Elliott outside this body of work include 35% ownership/investment interest in a medical consulting start up, Pain ID, LLC.

Clinical Trials Registration: not applicable

Main Outcome Measures—Short Form-36 Health Survey Physical Functioning subscale (SF-36 PFS), Timed Up and Go (TUG), gait speed, and fast stair descent performance.

Results—Interaction terms between L5 multifidi MFI and group assignment were found to be significant contributors to the variance explained in all physical function measures ($p \leq .012$). Neither the main effect, nor the interaction with group assignment for L5 multifidi rmCSA, significantly contributed to the variance explained in any of the physical function measures ($p > .012$).

Conclusions—Among older adults with chronic LBP of at least moderate intensity, L5 multifidi muscle composition, but not size, may help to explain physical function.

Keywords

aged; magnetic resonance imaging; paraspinal muscles

Seventy-seven percent of older adults who seek care for back pain will experience persistent symptoms and disability at 12 months.[1] Costs associated with spine-related treatment and disabilities are disproportionately higher for individuals with persistent, i.e. chronic, LBP as compared to those experiencing their first episode of pain.[2] For example, the total direct costs over a 12 month period for treatment and follow-up of a single patient with chronic LBP in the United States has been estimated to be $2426.[3] Contributing to these costs are the large utilization of surgery- and specialty-care services among older adults with chronic LBP.[4] Identification of modifiable factors that might be addressed with targeted rehabilitative programs among older adults with chronic LBP may reduce the physical and financial burdens of this chronic condition.

Trunk muscles, such as the lumbar multifidi, which play a major role in spinal function,[5] are impaired in adults with chronic LBP.[6,7] Specifically, Wan and colleagues found that individuals with chronic, unilateral LBP have reductions in multifidi muscle CSAs at multiple levels on the symptomatic side, which may occur prior to changes in muscle quality, i.e. increased fatty infiltration.[7] From a rehabilitation standpoint, among those with and without chronic LBP, prolonged exercise programs targeting the trunk muscles (e.g. stabilization exercises, stabilization exercises plus dynamic-static resistance exercises) have been shown to increase multifidi CSA.[8] Few studies, however, have linked multifidi size to physical function in adults with LBP.[9]

Among older adults, gait speed[10] and timed stair negotiation[11,12] are commonly utilized, performance-based measures of physical function. Reduced gait speed is predictive of greater disability, falls, hospitalization, institutionalization, and early mortality in older, community-dwelling adults.[10,13] Difficulty with stair negotiation is associated with multiple co-morbidities,[14] and is rated by older adults as one of the most-challenging tasks due to “old-age”.[15] Thus, identifying trunk muscle impairments that are associated with reduced gait speed and poorer stair performance among older adults may assist with developing interventions that enhance clinical outcomes related to physical function, as well as other metrics of health. Older adults with chronic LBP may be an ideal population for such studies, given that both aging and LBP have a negative impact on trunk muscle.

Age-related trunk muscle impairments include atrophy and/or increased intramuscular fat.[16,17] With respect to physical function, evidence suggests that muscle quality, i.e. intramuscular fat, may be more important than size.[18,19] Among older, community-dwelling adults, increased muscle (i.e. abdominals and paraspinals) density (i.e. decreased intramuscular fat), has been associated with reduced postural sway and better functional performance.[20] Among older adults with and without LBP, Hicks and colleagues found greater trunk muscle (i.e. abdominals and paraspinals) intramuscular fat was predictive of poorer performance; LBP moderated this relationship.[19] Further exploration of intramuscular fat of the lumbar multifidi (given its role in spinal health and function) as a factor that may help to explain physical function among older adults, especially those with LBP, may expand upon these prior findings.[19,20]

Magnetic resonance imaging (MRI) affords a quantitative measure for delineating fat from muscle and can be used to measure muscle-fat infiltration (MFI), as well as relative muscle cross-sectional area (rmCSA - i.e. total CSA minus intramuscular fat CSA).[21] Furthermore, the collection of both self-report function- and pain-related questionnaires and objective performance-based measures provide insight into physical function among older adults. The purpose of this cross-sectional analysis was to determine if multifidi rmCSA and MFI as obtained via MRI were independently associated with self-reported and performance-based physical function in older adults with and without chronic LBP. It was hypothesized that multifidi MFI, but not rmCSA, would be independently associated with physical function, but that such relationships would be stronger among older adults with chronic LBP than relationships found among older adults without LBP.

Methods

Participants

Community-dwelling older adults, aged 60-85 years, with chronic LBP were recruited via advertisements near the University of Delaware, Newark, Delaware from May 2009 through December 2011 for a parent study.[22] To be included, volunteers with LBP had to have a pain intensity of ≥3/10 for ≥3 months. Older adult volunteers, ages 60-85 years, without LBP were concurrently recruited through community centers and advertisements. Individuals, regardless of LBP status, were excluded if they had a history of low back surgery, had received services for LBP within the past 6 months, had experienced a recent traumatic event, or if he/she had a neurological disorder or terminal illness. In a clinical research laboratory, participants signed the informed consent prior to their standardized evaluation by a licensed physical therapist that included height and weight for calculation of body mass index (BMI), as well as self-report and performance-based measures of physical function. This study was conducted in accordance with a protocol approved by the Institutional Review Board for Human Subjects Research at the University of Delaware.

Physical Function Measures

The Medical Outcomes Short Form-36 Health Survey (SF-36) has established psychometric properties.[23] It is comprised of 8 subscales, including the physical functioning scale (PFS), which has been found to have good discriminant validity between patients with and without major medical issues.[24] Each subscale has a maximal norm-based score of 100, with 50 representing “average” health, and greater scores indicating better health status[25]; the SF-36 PFS was used to capture self-reported function.

The Timed Up and Go (TUG), self-selected gait speed, and fast stair descent were used to evaluate performance-based function. The TUG is a reliable and valid measure where the participant is asked to rise from a chair with armrests, walk 3 meters, turn around, walk back to the chair, and sit down.[26] The average of three trials was determined. For self-selected gait speed, participants were asked to walk 2.44 meters at their usual pace; space for acceleration and deceleration was provided.[27] Gait speed, as assessed over short distances, has been shown to have excellent reproducibility.[28] For the fast stair descent, participants were timed as they descended 12 steps (depth: 28cm, height: 17cm) “as quickly and as safely as possible”. The average of two trials was calculated. Measuring stair ascent and descent separately among older adults is recommended.[14]

Magnetic Resonance Imaging

Within 48 hours of the on-site evaluation, individuals received a safety screen with an experienced technician and underwent supine MRI of the lumbar spine at a nearby imaging facility. Images were obtained on a 1.5 Tesla scanner[a] with a flexible spine coil. T1-weighted, spin-echo images were produced in the axial plane (repetition time/echo time=879/13ms; field of view=230mm×230mm; encoding matrix=480×640; phase encoding direction=anterior-to-posterior; bandwidth=180; flip angle=150 degrees; slice thickness=5mm with 1.5mm gap; acquisition time~8 minutes).

Data Processing

Using Image J software[b], all images were scaled, and rCSA measurements were taken by tracing just inside the fascial borders of the L5 multifidi muscles. L5 was selected over more proximal lumbar levels given that the L5/S1 region, which is a transitional zone, experiences the greatest shear forces in the lumbar region.[29] Thus, active restraints, such as the lumbar multifidi may be critical to function in this region. Using the histogram function, pixel intensity summaries were obtained for rCSAs and .5cm×.5cm areas of extramuscular fat lateral to the multifidi on both the right and left sides. MFIs were computed as mean rCSA pixel intensity/mean extramuscular fat pixel intensity. To remove T1-weighted fat from rCSA to determine relative muscle CSA, i.e. rmCSA, the following equation was used: rmCSA = (1-MFI)*rCSA. Right and left sides were averaged for each of the independent variables, i.e. MFI and rmCSA, after checking to be sure that there were no significant differences between the sides for either group (α>.050), including no differences between sides for individuals with unilateral LBP (α>.050). Reliability for this assessment technique has been previously published.[30]

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[a]1.5 Tesla scanner Siemens MAGNETOM, Erlangen, Germany. Available at: http://usa.healthcare.siemens.com/magnetic-resonance-imaging/0-35-to-1-5t-mri-scanner/magnetom-avanto

[b]Image J software, Bethesda, Maryland. Available at: http://imagej.nih.gov/ij/

Statistical Analyses

Statistical analyses were performed using IBM SPSS Statistics 23[c]. Demographics, physical function, and MRI-obtained muscle characteristic data were summarized and independent t-tests (and analysis of covariance) were used to evaluate between-group differences (α=.050). Linear regression was used to explore relationships between MRI-obtained characteristics of L5 multifidi (i.e. MFI and rmCSA) and physical function. Suspected covariates (i.e. age, sex, BMI) were entered into the first step of each model. The main effect for LBP status was assessed in the second step of each model, followed by the main effect for the MRI-obtained characteristic of the L5 multifidi in the third step. Finally, the interaction between LBP status and the MRI-obtained characteristic of the L5 multifidi was entered into the final step. A Bonferroni correction was applied to the models to control for familywise error rate (α=.012). Independent sets of regression models were run for each dependent variable: the SF-36 PFS, the TUG, gait speed, and fast stair descent. Post-hoc, alternate modeling, where BMI was removed from the models, was used to assess the amount of variance shared between BMI and L5 multifidi MFI.

Model residuals were evaluated for normality using the Kolmogorov-Smirnov and Shapiro-Wilk tests. Outliers were removed. Assumptions for linear regression modeling were met.

Results

Table 1 displays the participant characteristics. There were no statistically significant differences between right and left sides for MFI or rmCSA for either group (p>.050). Sex, age, and rmCSA of L5 multifidi distributions were similar between those with and without CLBP, but those with chronic LBP had significantly higher BMIs and multifidi MFIs. Individuals with LBP had significantly worse self-reported physical function, slower gait speeds, and reduced TUG and stair descent performance, when compared to controls (p<.050); these differences remained even after controlling for BMI (p<.050).

Table 2 depicts the relationships between multifidi MFI and physical function, beyond suspected covariates and LBP presence. To investigate whether the relationships between MFI and physical function differed based on LBP presence, an interaction term was entered into the final step of each model. For SF-36 PFS, covariates explained 27.8% of the variance, while LBP presence independently explained 32.5% of the variance. Multifidi MFI explained an additional 3.1% of the variance, while the interaction term explained an additional 5.4% of the variance; ten outliers were removed to achieve normality of residuals. For TUG performance, covariates explained 30.9% of the variance, while LBP presence independently explained 11.5% of the variance. The interaction term explained an additional 3.7% of the variance; four outliers were removed. For gait speed, covariates and pain explained 29.0% of the variance, and the interaction term explained less than 1% of additional variance; three outliers were removed. For fast stair descent performance, covariates explained 37.4% of the variance, pain presence explained an additional 7.8% of the variance, and the interaction term explained an additional 4.1% of the variance; four outliers were removed. Figure 1 illustrates the interaction effect between chronic LBP

[c]IBM SPSS Statistics 23, Armonk, New York. Available at: http://www.ibm.com/us-en/

presence and MFI for each of the dependent, i.e. physical function, variables. Among older adults with chronic LBP, as MFI increased, self-reported function per the SF-36 PFS and gait speed decreased, while time to complete the TUG and fast stair ascent increased. Table 3 indicates that with BMI removed from the models, a greater percentage of the variance in physical function was explained by the interaction term.

Table 4 depicts the relationships between multifidi rmCSA and physical function, beyond the influence of covariates and LBP presence, as well as, the influence of the interaction term. For SF-36 PCS, covariates and the main effect for LBP presence explained 28.6% and 32.5% of the variance, respectively; nine outliers were removed. For TUG performance, covariates and LBP presence explained 34.5% and 10.7% of the variance, respectively; five outliers were removed. For gait speed, covariates and the main effect for LBP presence explained 20.6% and 7.5% of the variance, respectively; three outliers were removed. For fast stair descent performance, covariates and the main effect for LBP presence explained 40.2% and 7.3% of the variance, respectively; five outliers were removed. Neither the main effect for multifidi rmCSA nor the interaction term significantly contributed to any of the models ($p>.012$).

Discussion

This study confirms that older adults with chronic LBP have worse self-reported and performance-based physical function, when compared to their peers without LBP. This study, however, is among the first to specifically evaluate lumbar *multifidi* intramuscular fat as it relates to physical function among older adults. Our hypotheses are supported; multifidi intramuscular fat may help to explain both self-reported and performance-based physical function among older adults with chronic LBP. As L5 multifidi intramuscular fat increases, physical function decreases in older adults with moderate-intensity, chronic LBP. L5 multifidi MFI is related to BMI among older adults with chronic LBP but MFI also shares an independent relationship, albeit small, with physical function. Multifidi size, regardless of LBP presence, does not help to explain physical function. Further, among older adults without LBP, relationships between muscle morphology and physical function were not found, supporting our hypothesis that such relationships may be unique in the presence of chronic LBP.

In 2015, Suri and colleagues[9] concluded that there was limited evidence that lumbar paraspinal muscle size or quality were associated with LBP outcomes. The only study exploring relationships among older adults in the systematic review[9] was by Hicks and colleagues[19]. Hicks et al. findings[19] alongside our results suggest that trunk muscle intramuscular fat *is* related to both objective measures of physical function, as well as patient perceptions of said physical function in older adults with chronic LBP. Our results are consistent with previous findings[9,18] that posterior trunk muscle size is not associated with physical function among older adults. In fact, post-hoc testing found that a sample size of 438 (n=228 with LBP; n=210 without LBP) would be needed to detect a significant difference between the groups in multifidi size (80% power, alpha=0.05), indicating that older adults with and without chronic LBP are not as disparate on this muscle measure.

Greater multifidi intramuscular fat has been associated with increased risk of high-intensity pain and disability among middle-aged adults with LBP,[31] which is consistent with our finding that greater multifidi intramuscular fat was associated with worse self-reported physical function among our older adults with chronic LBP. Thus, treatments targeting a decrease in multifidi intramuscular fat may be a means of improving patient perceived-function and resultant disability; testing of this hypothesis through muscle regeneration research, including cellular studies and clinical trials among adults with LBP is needed.

Greater BMI is associated with worse performance-based physical function among older adults.[32] Thus, it is not surprising that BMI explained a large percentage of the variance in physical function in both groups of older adults. Among older adults with chronic LBP, when we removed BMI from the models, the variance explained by the interaction between LBP presence and L5 multifidi MFI increased for each dependent variable. This suggests that BMI and multifidi MFI are related among older adults with chronic LBP. Treatments targeting BMI may effectively also target multifidi MFI.

Higher BMIs are found among individuals with chronic LBP.[33,34] Importantly, even after controlling for BMI, our older adults with chronic LBP had worse physical function, when compared to their peers without LBP. Such findings are consistent with previous research[35-37] and emphasize the importance of evaluating not just back-related function, but also overall physical function, among older adults with chronic LBP.

Not unexpectedly, pain presence explained a significant percentage of the variance for all measures of physical function. Given the multifactorial nature of chronic pain, it is not surprising targeting pain has been shown to be an ineffective treatment strategy.[1] However, a targeted shift towards improving physical function rather than eliminating pain may prove beneficial.[38] Finding potentially modifiable factors that are linked to function (i.e. intramuscular fat, BMI), is particularly relevant given that older adults with chronic LBP demonstrate only small improvements in physical function with conservative interventions.[39] There exists evidence that trunk rehabilitation programs result in increased CSA[40] and while preliminary, there also exists evidence that trunk exercises may also improve muscle quality[41]. Specifically, Woodham et al.[41] reported that two young patients with chronic LBP who performed multifidi-focused exercises had reduced intramuscular fat. Given previous findings,[19,20] it is possible that older adults with LBP may also benefit from similar interventions.[42] Our work supports future research exploring longitudinal relationships between multifidi intramuscular fat and physical function among older adults with chronic LBP. Ultimately, if predictive relationships can be established using advanced, but available, imaging sequences, then future clinical trials that focus on improving multifidi composition as a treatment pathway for improving physical function among older adults with chronic LBP may be supported.

Study Limitations

As this was a secondary data analysis, sample size was not calculated *a priori*, but rather dependent on images acquired from prior studies. Data was obtained from T1-weighted images; newer MRI technology[43,44] may allow for a more accurate and rapid means for assessment of muscle composition. Further, since we evaluated only a single multifidi level;

it is possible that findings may differ at adjacent levels. Lack of side-to-side multifidi muscle differences for those with unilateral LBP may be due to the level selected (as this may not have been the symptomatic level), chronicity of the LBP (as the multifidi may be effected bilaterally),[45] and/or the small sample size. Due to laboratory space limitations, we used a 2.44 meter walking course to determine gait speed; recent evidence suggests that the 10 meter course may be more valid.[46] Since we included only older adults with chronic, moderate-intensity LBP, whether similar findings would be found in those with acute LBP and/or with less-intense LBP remains unknown. Further, activity level, which may impact muscle quality and physical function, was not evaluated in this study.

Conclusions

Older adults with chronic LBP have worse physical function than their peers without LBP. Among older adults with moderate chronic LBP, L5 multifidi muscle composition, but not size, may help to explain self-reported and performance-based physical function, beyond sex, age, and BMI. In simplistic terms, as multifidi intramuscular fat increased, self-report and performance-based physical function decreased in older adults with chronic LBP. Muscle quality (multifidi in this case) may be a targetable, modifiable factor for older adults with chronic LBP (and other common yet enigmatic musculoskeletal conditions). Future longitudinal research may evaluate the predictive value of multifidi muscle quality on physical function in this patient population. Ultimately, treatments targeting a decrease in intramuscular fat may be a mechanism for improving physical function among older adults with chronic LBP.

Acknowledgments

The study was funded, in part, by the National Institutes of Health [1K12HD05593-01, R21 HD057274, 1R01AG041202-01, T32HD007490-15]; the Foundation for Physical Therapy PODS I/II; and the Fellowship for Geriatric Research Award from the Academy of Geriatric Physical Therapy. The authors disclose that activities for Dr. Elliott outside this body of work include 35% ownership/investment interest in a medical consulting start up, Pain ID, LLC.

Financial Support: This project was partially funded by 1K12HD055931-01 (NIH). The work of Dr. Sions was supported in part by the Foundation for Physical Therapy PODS I/II, the Fellowship for Geriatric Research Award from the Academy of Geriatric Physical Therapy, R21 HD057274 (NICHD), and 1R01AG041202-01 (NIA). The work of Peter Coyle was supported in part by R21 HD057274 (NICHD), 1R01AG041202-01 (NIA), and T32HD007490-15. The work of Drs. Velasco and Hicks was supported in part by R21 HD057274 (NICHD) and R01AG041202-01 (NIA).

References

1. Rundell SD, Sherman KJ, Heagerty PJ, Mock CN, Jarvik JG. The clinical course of pain and function in older adults with a new primary care visit for back pain. J Am Geriatr Soc. 2015; 63:524–30. DOI: 10.1111/jgs.13241 [PubMed: 25754841]
2. Freburger JK, Holmes GM, Agans RP, Jackman AM, Darter JD, Wallace AS, Castel LD, Kalsbeek WD, Carey TS. The rising prevalence of chronic low back pain. Arch Intern Med. 2009; 169:251–8. DOI: 10.1001/archinternmed.2008.543 [PubMed: 19204216]
3. Mehra M, Hill K, Nicholl D, Schadrack J. The burden of chronic low back pain with and without a neuropathic component: a healthcare resource use and cost analysis. J Med Econ. 2012; 15:245–52. DOI: 10.3111/13696998.2011.642090 [PubMed: 22136441]

4. Stewart WF, Yan X, Boscarino JA, Maeng DD, Mardekian J, Sanchez RJ, Von Korff MR. Patterns of health care utilization for low back pain. J Pain Res. 2015; 8:523–35. DOI: 10.2147/JPR.S83599 [PubMed: 26316803]
5. Freeman MD, Woodham MA, Woodham AW. The role of the lumbar multifidus in chronic low back pain: a review. PM R. 2010; 2:142–6. DOI: 10.1016/j.pmrj.2009.11.006 [PubMed: 20193941]
6. Fortin M, Macedo LG. Multifidus and paraspinal muscle group cross-sectional areas of patients with low back pain and control patients: a systematic review with a focus on blinding. Phys Ther. 2013; 93:873–88. DOI: 10.2522/ptj.20120457 [PubMed: 23504343]
7. Wan Q, Lin C, Li X, Zeng W, Ma C. MRI assessment of paraspinal muscles in patients with acute and chronic unilateral low back pain. Br J Radiol. 2015; 88:20140546.doi: 10.1259/bjr.20140546 [PubMed: 26105517]
8. Kliziene I, Sipaviciene S, Klizas S, Imbrasiene D. Effects of core stability exercises on multifidus muscles in healthy women and women with chronic low-back pain. J Back Musculoskeletal Rehabil. 2015; 28:841–7. DOI: 10.3233/BMR-150596
9. Suri P, Fry AL, Gellhorn AC. Do muscle characteristics on lumbar spine magnetic resonance imaging or computed tomography predict future low back pain, physical function, or performance? a systematic review. PM R. 2015; 7:1269–81. DOI: 10.1016/j.pmrj.2015.04.016 [PubMed: 25952771]
10. Pamoukdjian F, Paillaud E, Zelek L, Laurent M, Levy V, Landre T, Sebbane G. Measurement of gait speed in older adults to identify complications associated with frailty: A systematic review. J Geriatr Oncol. 2015; 6:484–96. DOI: 10.1016/j.jgo.2015.08.006 [PubMed: 26362356]
11. Hinman MR, O'Connell JK, Dorr M, Hardin R, Tumlinson AB, Varner B. Functional predictors of stair-climbing speed in older adults. J Geriatr Phys Ther. 2014; 37:1–6. DOI: 10.1519/JPT.0b013e318298969f [PubMed: 23835772]
12. Judd DL, Thomas AC, Dayton MR, Stevens-Lapsley JE. Strength and functional deficits in individuals with hip osteoarthritis compared to healthy, older adults. Disabil Rehabil. 2014; 36:307–12. DOI: 10.3109/09638288.2013.790491 [PubMed: 23659184]
13. Peel NM, Kuys SS, Klein K. Gait speed as a measure in geriatric assessment in clinical settings: a systematic review. J Gerontol A Biol Sci Med Sci. 2013; 68:39–46. DOI: 10.1093/gerona/gls174 [PubMed: 22923430]
14. Verghese J, Wang C, Xue X, Holtzer R. Self-reported difficulty in climbing up or down stairs in nondisabled elderly. Arch Phys Med Rehabil. 2008; 89:100–4. DOI: 10.1016/j.apmr.2007.08.129 [PubMed: 18164338]
15. Williamson JD, Fried LP. Characterization of older adults who attribute functional decrements to “old age”. J Am Geriatr Soc. 1996; 44:1429–34. [PubMed: 8951311]
16. Sions JM, Tyrell CM, Knarr BA, Jancosko A, Binder-Macleod SA. Age- and stroke-related skeletal muscle changes: a review for the geriatric clinician. J Geriatr Phys Ther. 2012; 35:155–61. DOI: 10.1519/JPT.0b013e318236db92 [PubMed: 22107952]
17. Crawford RJ, Filli L, Elliott JM, Nanz D, Fischer MA, Marcon M, Ulbrich EJ. Age- and level-dependence of fatty Infiltration in lumbar paravertebral muscles of healthy volunteers. AJNR Am J Neuroradiol. 2016; 37:742–8. DOI: 10.3174/ajnr.A4596 [PubMed: 26635285]
18. Hicks GE, Simonsick EM, Harris TB, Newman AB, Weiner DK, Nevitt MA, Tylavsky FA. Cross-sectional associations between trunk muscle composition, back pain, and physical function in the health, aging and body composition study. J Gerontol A Biol Sci Med Sci. 2005; 60:882–7. [PubMed: 16079212]
19. Hicks GE, Simonsick EM, Harris TB, Newman AB, Weiner DK, Nevitt MA, Tylavsky FA. Trunk muscle composition as a predictor of reduced functional capacity in the health, aging and body composition study: the moderating role of back pain. J Gerontol A Biol Sci Med Sci. 2005; 60:1420–4. [PubMed: 16339328]
20. Anderson DE, Quinn E, Parker E, Allaire BT, Muir JW, Rubin CT, Magaziner J, Hannan MT, Bouxsein ML, Kiel DP. Associations of computed tomography-based trunk muscle size and density with balance and falls in older adults. J Gerontol A Biol Sci Med Sci. 2016; 71:811–16. DOI: 10.1093/gerona/glv185 [PubMed: 26503375]

21. Elliott JM, Pedler AR, Jull GA, Van Wyk L, Galloway GG, O'Leary SP. Differential changes in muscle composition exist in traumatic and nontraumatic neck pain. Spine (Phila Pa 1976). 2014; 39:39–47. DOI: 10.1097/BRS.0000000000000033 [PubMed: 24270932]
22. Hicks GE, Sions JM, Velasco TO, Manal TJ. Trunk muscle training augmented with neuromuscular electrical stimulation appears to improve function in older adults with chronic low back pain: a randomized preliminary trial. Clin J Pain. 2016; in press. doi: 10.1097/AJP.0000000000000348
23. Garratt AM, Ruta DA, Abdalla MI, Buckingham JK, Russell IT. The SF36 health survey questionnaire: an outcome measure suitable for routine use within the NHS? BMJ. 1993; 306:1440–4. [PubMed: 8518640]
24. McHorney CA, Ware JE Jr, Raczek AE. The MOS 36-Item Short-Form Health Survey (SF-36): II. Psychometric and clinical tests of validity in measuring physical and mental health constructs. Medical care. 1993; 31:247–63. [PubMed: 8450681]
25. Veresciagina K, Ambrozaitis KV, Spakauskas B. Health-related quality-of-life assessment in patients with low back pain using SF-36 questionnaire. Medicina. 2007; 43:607–13. [PubMed: 17895635]
26. Podsiadlo D, Richardson S. The timed “Up & Go”: a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc. 1991; 39:142–8. [PubMed: 1991946]
27. Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG, Scherr PA, Wallace RB. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. J Gerontol. 1994; 49:M85–94. [PubMed: 8126356]
28. Goldberg A, Schepens S. Measurement error and minimum detectable change in 4-meter gait speed in older adults. Aging Clin Exp Res. 2011; 23:406–12. [PubMed: 22526072]
29. El-Rich M, Aubin CE, Villemure I, Labelle H. A biomechanical study of L5-S1 low-grade isthmic spondylolisthesis using a personalized finite element model. Stud Health Technol Inform. 2006; 123:431–4. [PubMed: 17108464]
30. Sions JM, Smith AC, Hicks GE, Elliott JM. Trunk muscle size and composition assessment in older adults with chronic low back pain: an intra-examiner and inter-examiner reliability study. Pain Med. 2015; in press. doi: 10.1093/pm/pnv023
31. Teichtahl AJ, Urquhart DM, Wang Y, Wluka AE, Wijethilake P, O'Sullivan R, Cicuttini FM. Fat infiltration of paraspinal muscles is associated with low back pain, disability, and structural abnormalities in community-based adults. Spine J. 2015; 15:1593–601. DOI: 10.1016/j.spinee.2015.03.039 [PubMed: 25828477]
32. Vincent HK, Vincent KR, Lamb KM. Obesity and mobility disability in the older adult. Obe Rev. 2010; 11:568–79. DOI: 10.1111/j.1467-789X.2009.00703.x
33. Seyedmehdi SM, Dehghan F, Ghaffari M, Attarchi M, Khansari B, Heidari B, Yazdanparast T, Norouzi Javidan A, Emami Razavi SH. Effect of general health status on chronicity of low back pain in industrial workers. Acta Med Iran. 2016; 54:211–7. [PubMed: 27107527]
34. Rinaldo L, McCutcheon BA, Gilder H, Kerezoudis P, Murphy M, Maloney PR, Hassoon A, Bydon M. 341 Diabetes mellitus and back pain: markers of diabetes disease progression are associated with chronic back pain. Neurosurgery. 2016; 63(Suppl 1):200.doi: 10.1227/01.neu.0000489830.71012.d0
35. Ledoux E, Dubois JD, Descarreaux M. Physical and psychosocial predictors of functional trunk capacity in older adults with and without low back pain. J Manipulative Physiol Ther. 2012; 35:338–45. DOI: 10.1016/j.jmpt.2012.04.007 [PubMed: 22608282]
36. Hicks GE, Gaines JM, Shardell M, Simonsick EM. Associations of back and leg pain with health status and functional capacity of older adults: findings from the retirement community back pain study. Arthritis Rheum. 2008; 59:1306–13. DOI: 10.1002/art.24006 [PubMed: 18759261]
37. Rudy TE, Weiner DK, Lieber SJ, Slaboda J, Boston JR. The impact of chronic low back pain on older adults: a comparative study of patients and controls. Pain. 2007; 131:293–301. DOI: 10.1016/j.pain.2007.01.012 [PubMed: 17317008]
38. Govenden D, Serpell M. Improving outcomes for chronic pain in primary care. Practitioner. 2014; 258:13–7, 2.

39. Kuss K, Becker A, Quint S, Leonhardt C. Activating therapy modalities in older individuals with chronic non-specific low back pain: a systematic review. Physiotherapy. 2015; 101:310–8. DOI: 10.1016/j.physio.2015.04.009 [PubMed: 26414346]

40. Danneels LA, Vanderstraeten GG, Cambier DC, Witvrouw EE, Bourgois J, Dankaerts W, De Cuyper HJ. Effects of three different training modalities on the cross sectional area of the lumbar multifidus muscle in patients with chronic low back pain. Br J Sports Med. 2001; 35:186–91. [PubMed: 11375879]

41. Woodham M, Woodham A, Skeate JG, Freeman M. Long-term lumbar multifidus muscle atrophy changes documented with magnetic resonance imaging: a case series. J Radiol Case Rep. 2014; 8:27–34. DOI: 10.3941/jrcr.v8i5.1401

42. Saragiotto BT, Maher CG, Yamato TP, Costa LO, Menezes Costa LC, Ostelo RW, Macedo LG. Motor control exercise for chronic non-specific low-back pain. Cochrane Database Syst Rev. 2016; 1:CD012004.doi: 10.1002/14651858.CD012004

43. Smith AC, Parrish TB, Abbott R, Hoggarth MA, Mendoza K, Chen YF, Elliott JM. Muscle-fat MRI: 1.5 Tesla and 3.0 Tesla versus histology. Muscle Nerve. 2014; 50:170–6. DOI: 10.1002/mus.24255 [PubMed: 24677256]

44. Reeder SB, Hu HH, Sirlin CB. Proton density fat-fraction: a standardized MR-based biomarker of tissue fat concentration. J Magn Reson Imaging. 2012; 36:1011–4. DOI: 10.1002/jmri.23741 [PubMed: 22777847]

45. Beneck GJ, Kulig K. Multifidus atrophy is localized and bilateral in active persons with chronic unilateral low back pain. Arch Phys Med Rehabil. 2012; 93:300–6. DOI: 10.1016/j.apmr.2011.09.017 [PubMed: 22289241]

46. Peters DM, Fritz SL, Krotish DE. Assessing the reliability and validity of a shorter walk test compared with the 10-Meter Walk Test for measurements of gait speed in healthy, older adults. J Geriatr Phys Ther. 2013; 36:24–30. DOI: 10.1519/JPT.0b013e318248e20d [PubMed: 22415358]

Abbreviations

BMI	body mass index
LBP	low back pain
MFI	muscle-fat infiltration index
MRI	magnetic resonance imaging
rCSA	relative cross-sectional area
rmCSA	relative muscle cross-sectional area
SF-36 PFS	Short Form-36 Health Survey Physical Functioning subscale
TUG	Timed Up and Go

Highlights

- Greater intramuscular fat is found among older adults with chronic low back pain.
- Multifidi quality is associated with physical function in adults with back pain.
- Multifidi muscle size is not associated with physical function in older adults.

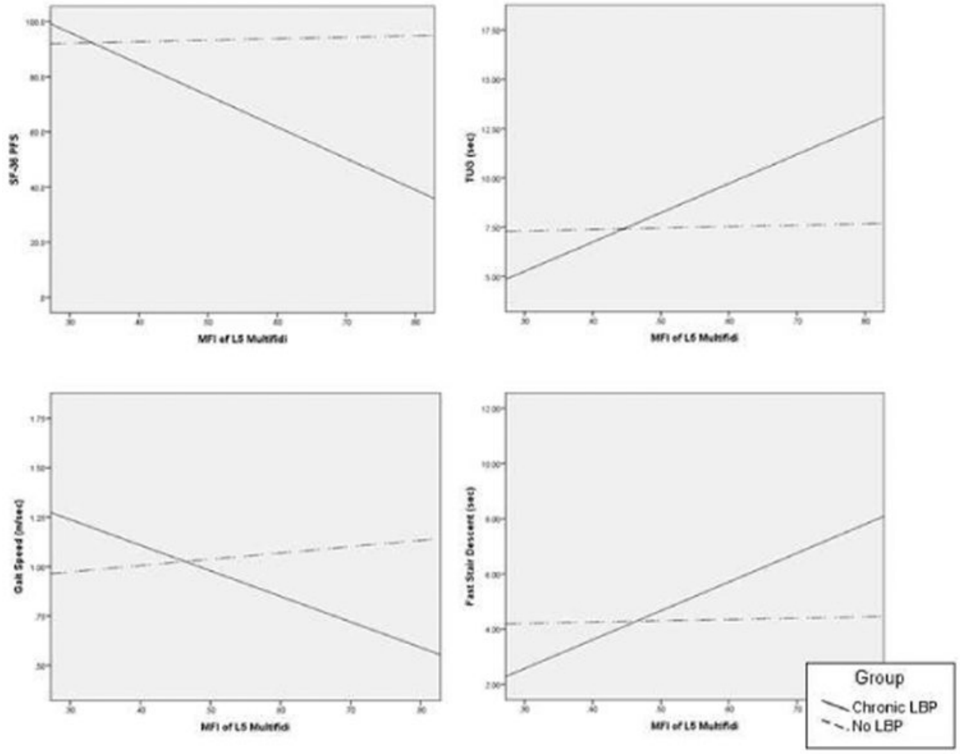

Figure 1. Interaction Effect of Chronic LBP Presence in the Relationship between L5 Multifidi MFI and Physical Function

As MFI increased, physical function decreased for older adults with chronic LBP when compared to older adults without LBP. MFI, Muscle-Fat Infiltration index; SF-36 PFS, Short Form-36 Physical Functioning Scale; TUG, Timed Up-and-Go; LBP, Low Back Pain.

Table 1

Participant Characteristics

	Chronic LBP (n=57)	No LBP (n=49)	p-value
	n (%)		
Sex (females)	33 (57%)	34 (69%)	.234
	mean (SD)		
Age (years)	70.5 ± 6.8	72.2 ± 6.6	.214
BMI (kg/m^2)	29.6 ± 5.8	27.3 ± 4.59	.026
SF-36 PFS Score	66.31±23.00	91.91±10.13	.000
Timed Up and Go (sec)	9.53±3.13	7.52±1.51	.000
Gait Speed (m/sec)	.91±.21	1.02±.21	.006
Fast Stair Descent (sec)	5.94±3.93	4.45±1.40	.014
L5 Multifidi rCSA (cm^2)	10.31 ± 2.00	9.84 ± 1.94	.792
L5 Multifidi MFI	.55 ± .09	.51 ± .08	.034
L5 Multifidi rmCSA (cm^2)	4.55 ± 1.19	4.72 ± 1.15	.229

Abbreviations: LBP, low back pain; SD, standard deviation; BMI, body mass index; SF-36 PFS, Short Form-36 physical functioning subscale; rCSA, relative cross sectional area; MFI, muscle-fat infiltration index; rmCSA, relative muscle cross-sectional area.

Table 2
Linear Regression Models for L5 Multifidi MFI and Physical Function

Model	R^2	Adjusted R^2	R^2 Change	p-value
Dependent Variable = SF-36 PFS score				
1	.278	.254	.278	<.001 *
2	.604	.586	.325	<.001 *
3	.635	.614	.031	.008 *
4	.689	.667	.054	<.001 *
Standardized β (p-value) of interaction term = 3.88 (<.001)				
Dependent Variable = TUG Performance				
1	.309	.287	.309	<.001 *
2	.423	.399	.115	<.001 *
3	.444	.415	.021	.063
4	.481	.448	.037	.011 *
Standardized β (p-value) of interaction term = -1.19 (.011)				
Dependent Variable = Gait Speed				
1	.206	.181	.206	<.001 *
2	.280	.251	.075	.002 *
3	.285	.247	.004	.454
4	.361	.321	.007	.001 *
Standardized β (p-value) of interaction term = 1.75 (<.001)				
Dependent Variable = Fast Stair Descent Performance				
1	.374	.354	.374	<.001 *
2	.451	.428	.078	<.001 *
3	.460	.431	.008	.229
4	.500	.468	.041	.007 *
Standardized β (p-value) of interaction term = -1.2 4 (.007)				
Model 1: age, sex, and body mass index				
Model 2: Model 1 + pain group (i.e. chronic LBP or no LBP)				
Model 3: Model 2 + L5 multifidi MFI				
Model 4: Model 3 + group × L5 multifidi MFI interaction term				

* Statistical significance (p≤.012)

Abbreviations: MFI, muscle-fat infiltration index; SF-36 PFS, Short Form-36 Health Survey Physical Functioning Scale score; TUG, Timed-Up-and-Go; LBP = low back pain.

Table 3

Linear Regression Models for L5 Multifidi MFI and Physical Function with Body Mass Index Removed

Model	R^2	Adjusted R^2	R^2 Change	p-value
Dependent Variable = SF-36 PFS score				
1	.025	.254	.046	<.119
2	.453	.586	.407	<.001 *
3	.531	.614	.078	<.001 *
4	.616	.667	.085	<.001 *
Standardized β (p-value) of interaction term = 1.80 (<.001)				
Dependent Variable = TUG Performance				
1	.097	.079	.097	.007 *
2	.247	.247	.172	<.001 *
3	.301	.301	.060	.004 *
4	.361	.361	.063	.002 *
Standardized β (p-value) of interaction term = -1.53 (.002)				
Dependent Variable = Gait Speed				
1	.079	.060	.079	.017
2	.191	.166	.113	<.001 *
3	.213	.181	.022	.104
4	.317	.281	.104	<.001 *
Standardized β (p-value) of interaction term = 2.00 (<.001)				
Dependent Variable = Fast Stair Descent Performance				
1	.149	.132	.149	<.001 *
2	.281	.258	.132	<.001 *
3	.319	.290	.038	.024
4	.392	.359	.073	.001 *
Standardized β (p-value) of interaction term = -3.3 5 (.001)				
Model 1: age and sex				
Model 2: Model 1 + pain group (i.e. chronic LBP or no LBP)				
Model 3: Model 2 + L5 multifidi MFI				
Model 4: Model 3 + group × L5 multifidi MFI interaction term				

* Statistical significance (p≤.012)

Abbreviations: MFI, muscle-fat infiltration index; SF-36 PFS, Short Form-36 Health Survey Physical Functioning Scale score; TUG, Timed-Up-and-Go; LBP = low back pain.

Table 4

Linear Regression Models for L5 Multifidi rmCSA and Physical Function

Model	R^2	Adjusted R^2	R^2 Change	p-value
Dependent Variable = SF-36 PFS score				
1	.286	.263	.286	<.001 *
2	.611	.593	.325	<.001 *
3	.628	.606	.017	.050
4	.644	.619	.016	.049
Standardized β (p-value) of interaction term = -.567 (.049)				
Dependent Variable = TUG Performance				
1	.345	.325	.345	<.001 *
2	.453	.430	.107	<.001 *
3	.453	.424	.000	.920
4	.453	.417	.000	.920
Standardized β (p-value) of interaction term = .033 (.920)				
Dependent Variable = Gait Speed				
1	.206	.181	.206	.000 *
2	.280	.251	.075	.002 *
3	.283	.246	.003	.551
4	.289	.244	.006	.392
Standardized β (p-value) of interaction term = -.326 (.392)				
Dependent Variable = Fast Stair Descent Performance				
1	.402	.383	.402	<.001 *
2	.475	.452	.073	<.001 *
3	.475	.447	.000	.854
4	.509	.477	.035	.013
Standardized β (p-value) of interaction term = .807 (.013)				
Model 1: sex, age, and body mass index				
Model 2: Model 1 + group (i.e. chronic LBP or no LBP)				
Model 3: Model 2 + L5 multifidi rmCSA				
Model 4: Model 3 + group × L5 multifidi rmCSA interaction term				

*Statistical significance (p≤.012)

Abbreviations: rmCSA, relative muscle cross-sectional area; SF-36 PFS, Short Form-36 Health Survey Physical Functioning Scale score; TUG, Timed Up and Go; LBP, low back pain.