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Original Research Article

Magnetic resonance imaging evaluation of age and level dependence of multifidus fatty infiltration in normal Indian healthy volunteers

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ABSTRACT

Background: Multifidus is one of the main stabilizers of lumbar spine. Fatty infiltration of multifidus varies with the age, sex, side and level of spine studied. The present study aims at the evaluation and comparison of the trends of multifidus fatty infiltration in normal population at various levels in both genders, side and different decade groups in healthy individual volunteers.
Methods: Twenty-five normal healthy volunteers equally distributed across different age groups (3^{rd}-7^{th} decades) formed the healthy study group. In step 1, normal population magnetic resonance (MR) images are collected and evaluated individually. In step 2, fatty infiltration of all people ascending in age was calculated at each lumbar level and on either side. In step 3, normal population were divided into decades and fatty infiltration at each decade and segment wise comparison was done. In step 4, statistical analysis of significance was done between the groups. All the T2 MR images were measured using Image j 1.50i software. Exclusion criteria included no proper visualization of paraspinal musculature in the T2 MR images. Associated conditions affecting the degeneration (other lytic lesions/vertebral fractures-healed or unhealed). Other etiology included disc prolapse, listhesis, infections, tumors, and trauma. For each MRI scan, at least 3 cuts for each segment were obtained in which the central cut will be selected for measurement.
Results: In study population, at all age groups the multifidus fatty infiltration (MFI) at all given levels upper lumbar levels (L1-2, L2-3) showed less fatty infiltration than lower levels. With increasing age there is increase in MFI in all levels. On either side, as the age increases fat % increases and in individual people as the segment going caudal the fat % increases. At each segment left side has more fat % than right side and overall fat % increase from L1 to S1 levels. As decades increases fat % increases in each individual segment, and also fat % increases from cephalad to caudal. There is a rapid increase in fat % transition from 4^{th} to 5^{th} decade. Overall fat % increase is seen from L1 to S1 in each decade. Females L1-2 to L3-4 does not show significant fat % increase. There are more fat % in females than males in lower lumbar levels, but the body mass index (BMI), daily activities may be a confounding factor.
Conclusions: Lumbar paravertebral muscle fat content increases with aging, in healthy volunteers 3^{nd} to 7^{th} decade of age. Women, low lumbar levels, left side the multifidus muscle are most affected.

Keywords: Multifidus, Fatty infiltration, Lumbar spine, Multifidus fatty infiltration

INTRODUCTION

Multifidus is one of the main stabilisers of lumbar spine. Fatty infiltration of multifidus varies with the age, sex, side and level of spine studied. The present study aims at identifying the fatty infiltration of multifidus muscle at various levels of lumbar spine and also the corresponding changes with age and side in healthy individual volunteers.

The evaluation and comparison of the trends of multifidus fatty infiltration in normal population at various levels in both genders, side and different decade age groups are studied.

Magnetic resonance (MR) imaging is the criterion standard for evaluating the size and structure of soft-aqueous skeletal muscles.[1,2] While T1WI is commonly used for qualitative assessment of muscle fat infiltration (MFI).[3,4] chemical-shift–based imaging sequences allow quantification, which correlates with clinical symptoms and histology.[2,3,5-9] Excellent accuracy for multifidus fatty infiltration quantification is shown in comparison with T1WI, spectroscopy, and histology in different animal species.[5,9,12] Accordingly, Dixon MR imaging was used for evaluating muscle fat content in several clinical studies including patients with low back pain (LBP), acute-to-chronic whiplash, and neuromuscular disorders.[5,13-15] Quantification of degeneration (fat infiltration and atrophy) of lumbar paravertebral muscles has attracted interest in understanding their biologic influence on persistent LBP. Atrophy and fat infiltrates are identified in patients and following experimentally induced lesions in a porcine model.[16-21,22] However, human studies describing lumbar multifidus fatty infiltration report inconsistent findings: An association with LBP was demonstrated in some but not in others.[13,16,18,23-26]

One explanation for discrepant findings is the influence of age on muscle composition.[17,18,27-29] Spinal degeneration is known to occur early and increasingly throughout the life span, yet to our knowledge, no study has assessed age-related morphologic changes to lumbar paravertebral muscles in healthy volunteers, which would provide a crucial supplement for future comparative studies.[30]

We would like to quantify lumbar paravertebral muscle fat content by MR imaging in healthy adult volunteers spanning 5 decades of life. we aimed to establish an age- and level dependent reference of lumbar paravertebral muscle fat content as a reflection of natural aging history. We hypothesize greater multifidus fatty infiltration with age for both sexes and its level dependence with an increasing craniocaudal trend.

METHODS

This cross-sectional observational study was conducted in the department of radio-diagnosis, Rajarajeswari Medical College and Hospital during the period March 2022 to August 2022. After obtaining clearance and approval from the institutional ethics committee and keeping in accordance with the Helsinki declaration, patients were screened and those who fulfilled the inclusion and exclusion criteria were enrolled in the study. A written informed consent was obtained from these patients. Twenty-five normal healthy volunteers equally distributed across different age groups (3rd-7th decades) formed the healthy study group. In step 1, normal population MR images are collected and evaluated individually. In step 2, fatty infiltration of all people ascending in age was calculated at each lumbar level and on either side. In step 3, normal population are divided into decades and fatty infiltration at each decade and segment wise comparison was done. In step 4, statistical analysis of significance done between the groups.

Imaging protocol

The imaging protocol will be standardised in the following fashion: T1 weighted sagittal images will be obtained with the following parameters: repetition time (TR)/echo time (TE), 560/12 ms; matrix, 384×288; sequence time, 2 min 44 s; field of view (FOV), 32×32 cm; number of excitations (NEX), 4; slice thickness, 4 mm; slice gap interval, 0.5 mm; T1 weighted transverse images will be obtained with the following parameters: TR/TE, 600/12 ms; matrix 320×224; sequence time, 2 min 20 s; FOV, 20×20 cm; NEX, 3; slice thickness, 4 mm; slice gap interval, 0.5 mm. T2 weighted sagittal and transverse fast spin echo images will be obtained with the following parameters: TR/TE, 3600/115 ms; matrix, 448×224; sequence time, 3 min 20 s; FOV, 32×32 cm for sagittal and 20×20 cm for transverse; slice thickness, 4 mm; slice gap interval, 0.5 mm.

For each MRI scan, level of affected pathology along with above and below normal segments will be measured. Atleast 3 cuts for each segment is obtained in which the central cut will be selected for measurement.

Exclusion criteria

No proper visualisation of paraspinal musculature in the T2 MR images. Associated conditions affecting the degeneration (other lytic lesions/vertebral fractures-healed or unhealed). Other etiology included disc prolapse, listhesis, infections, tumors, and trauma.

Statistical analysis

Data collected was analysed using descriptive and inferential statistics and the software used for analysis was Microsoft excel spreadsheet and statistical package for social sciences (SPSS) version 26.0.

RESULTS

Our study including twenty-five normal population of 14 males and 11 females decade wise distribution is depicted in Table 1. At all age groups the % of fat, at all given levels upper lumbar levels (L1-2, L2-3) showed less fatty infiltration than lower levels on both sides (Figures 1 and 2). With increasing age there is increase in fat in all levels (Figure 4). Significant increase in MFI% is seen in early decades than compared to latter decades ($p<0.002$). Females showed less cross-sectional area and more MFI% than males. Left side multifidus showed more muscle cross section area than right side. Left side showed more

increase in fat% than right side in all decades but not significant (Figure 3).

Table 1: Decade distribution of male and female population.

Decade distribution	Males	Females
3rd decade	2	3
4th decade	4	1
5th decade	3	2
6th decade	2	3
7th decade	3	2
Total	14	11

In all 25 normal people on right side, as the age increases MFI % increases. And in individual people as the segment going caudal the MFI % increases (Figure 1). In all 25 normal people on left side, as the age increases MFI % increases, and in individual people as the segment going caudal the MFI % increases (Figure 2).

At each segment left side has more MFI % than right side, and overall MFI % increase from L1-L2 to L5-S1 levels (Figure 3). As decades increases MFI % increases in each individual segment, and also MFI % increases from cephalad to caudal. There is a rapid increase in MFI % transition from 4th to 5th decade.

Overall MFI % increase is seen from L1-2 to L5-S1 in each decade. As the decades increases the MFI % increases and also MFI % increases from cephalad to caudal (Figure 5).

Compared in males and females L1-2 to L3-4 does not show significant MFI% increase. There are more MFI % in females than males in lower lumbar levels, but the BMI, activities of daily living may act as a confounding factor, so we have not included it in our study.

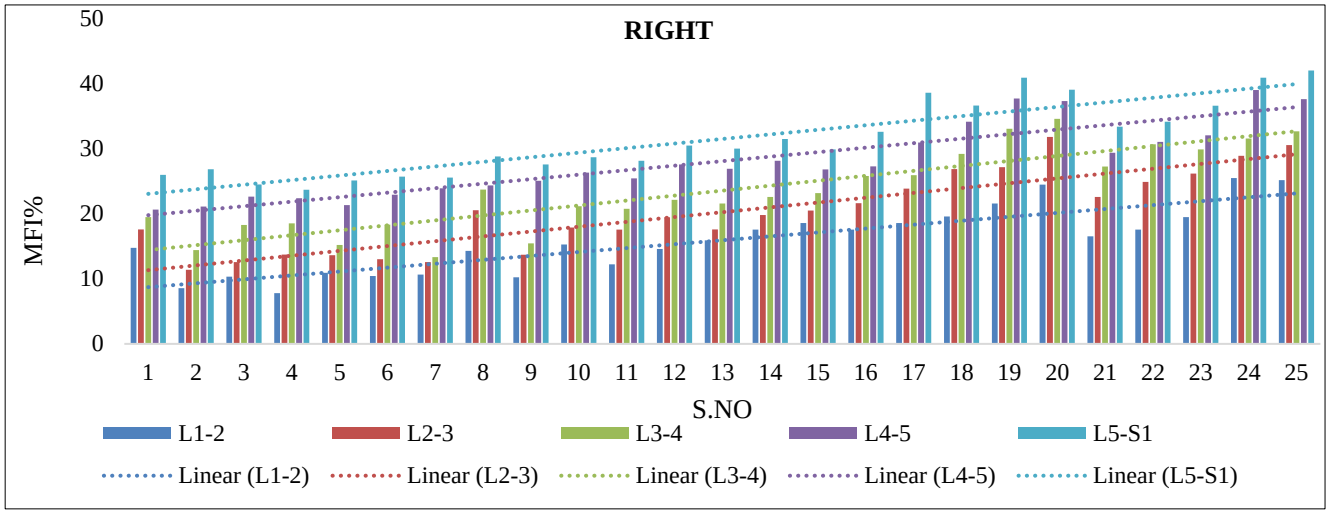

Figure 1: MFI% at lumbar levels on right side in ascending order of age.

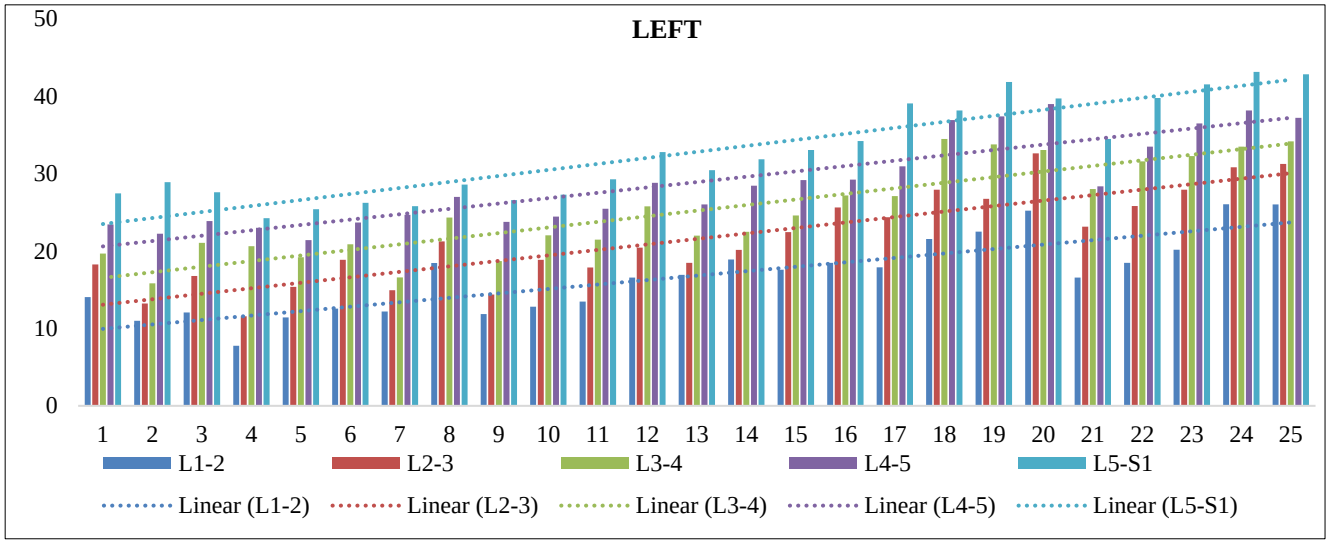

Figure 2: MFI% at lumbar levels on left side in ascending order of age.

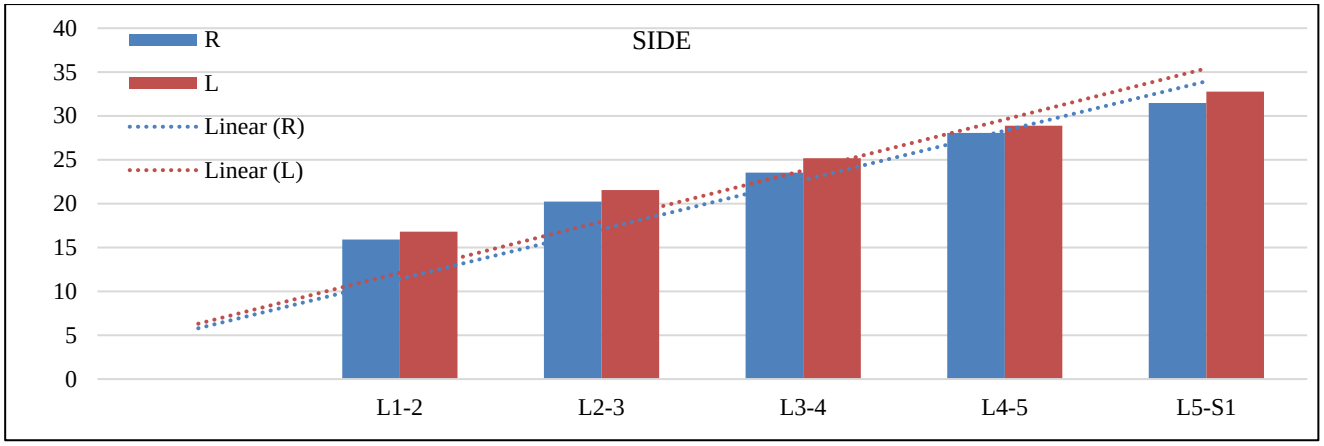

Figure 3: MFI% comparison on right and left side at different levels.

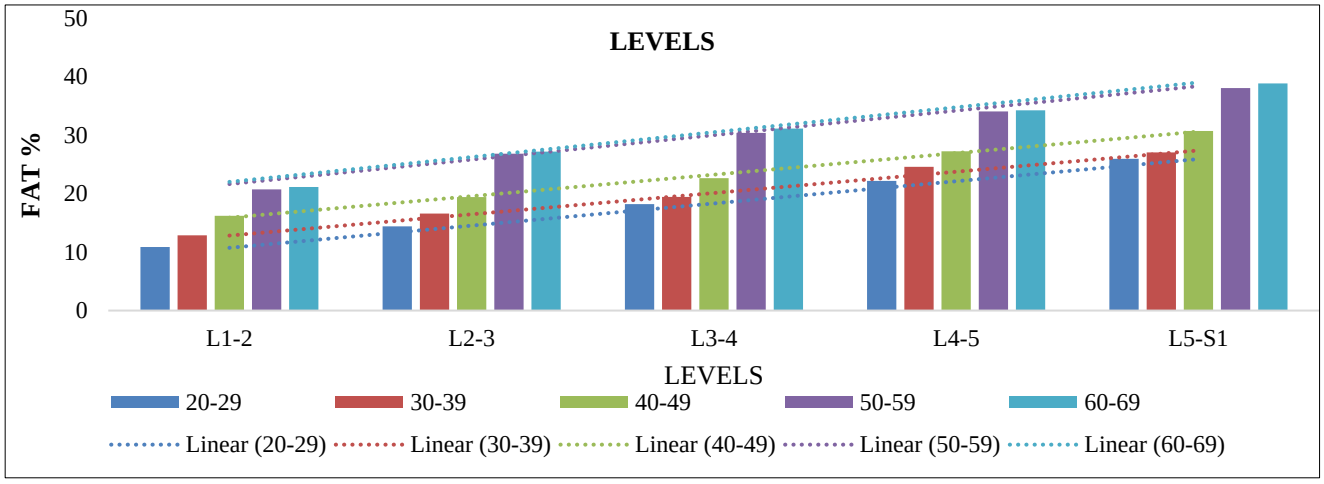

Figure 4: MFI% in all decades at averaged different levels.

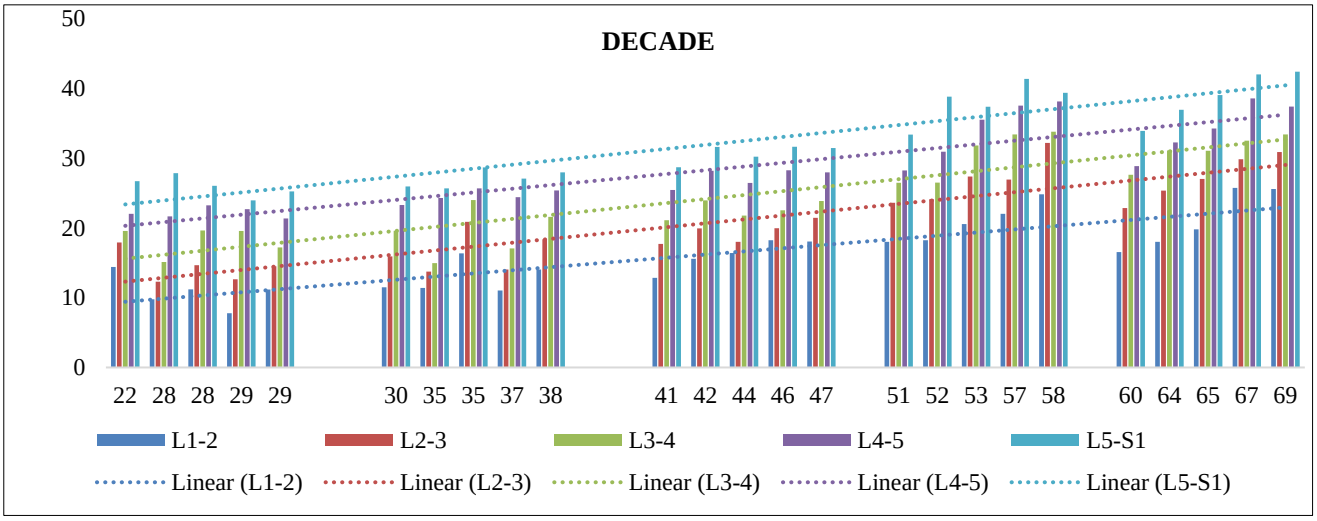

Figure 5: Average MFI% at all ages at different levels.

DISCUSSION

We quantified lumbar paravertebral muscle volume and fat content by MR imaging of 25 healthy adult volunteers (22–69 years of age) and showed that the lumbar paravertebral muscle fat increased with age. Women, low lumbar levels, and multifidus muscles were most affected; these findings align with degenerative features of the spinal column that are highly prevalent in asymptomatic individuals.[30]

Lumbar paravertebral muscle degeneration occurs in LBP and in response to induced lesions, yet its prognostic value is unclear.[16-20,22,24] Little is known about normative degeneration, and comparisons with existing literature are limited. Using similar quantification methods with axial MR imaging at 1.5T, Fischer et al described mean fat signal fraction within a region of bilateral multifidus muscles of 21% (range, 3–65%).[5]

Our fat content age effect agrees with that in other studies reporting MFI in subjects with and without back pain.[17,24,25,29] In disagreement, Fortin et al found no correlation with age and fat signal fraction cross-sectional areas at L3–L4 or L5–S1 derived from T2WI in men 35–69 years of age.[18] This likely reflects methodologic differences and may relate to their lack of cases representing the 20- to 30-year age group, further highlighting the need for consistency in quantifying paravertebral muscle quality. We found an age-related increase of MFI for both sexes, suggesting progressive worsening in muscle quality, even in healthy individuals. older age group had significantly more MFI than the youngest, the fourth to fifth decade transition of life is an effective baseline for paravertebral muscle degeneration in healthy people.

We showed an increasing craniocaudal trend for MFI between L1 and L5. Levels L5–S1 had higher MFI compared with the supradjacent level. This finding agrees with the longitudinal study of Fortin et al, in which L5–S1 had higher MFI than L3–L4.[17] D'Hooge et al showed more MFI bilaterally in subjects with LBP compared with healthy controls at both L4 endplates, yet equivalence at the L3 superior endplate.[31] While D'Hooge et al did not report interlevel comparisons, agreement exists with respect to a caudal trend for increasing MFI.[31] High paravertebral muscle volume occurs in people with greater lordotic angulation.[28] While there is conjecture about sex differences in lumbar curvature, determining spinal shape in relation to MFI could offer clarification.[32] Plausible explanations behind normative muscle atrophy and MFI exist and include a combination of disuse and denervation secondary to the degenerative cascade and concomitant altered tensile properties of lumbar myofascial and neural tissues. Disuse-related muscle decline purportedly relates to deconditioning, local tensile unload, and altered muscle recruitment.[16,19,22] Paravertebral muscle denervation occurs in asymptomatic individuals and the multifidus muscle is susceptible to the effects of neural stretching after disc height loss and subsequent listhesis.[33,34]

However, the extent of paraspinal muscle atrophy is not explained by matching denervation; this finding indicates the potential for reversal through activity.[35] We describe no association of FSF with BMI or exercise, perhaps not supporting either theory. Instead, a local disuse mechanism dependent on paravertebral muscle morphology and proximity to the vertebra as shown in the cervical spine might better explain the etiology.[36] Generally, men lose more muscle with aging, yet women have greater functional consequences.[37] Therefore, the influence of general body fat on healthy paravertebral MFI cannot be ignored.[29,31]

While our study has several strengths, it is limited by being cross-sectional, though it is feasible in assessing a wide age range. Identifying a baseline age group from which to reference the natural history of change represents a valuable contribution to the literature to which longitudinal studies can be directed. We only included participants 22–69 years of age; this age range may not be generalizable to other age groups. Our sample included 5 cases per decade, offering an improvement to the findings in the literature, but was potentially inadequately powered for reference as normative data. Other limitation includes, we have not compared the study between males and females. Other factors limited our study are BMI, activity for daily living which play a key role in affecting the multifidus fatty infiltration. Our healthy volunteers evidenced declining muscle quality as a normal process of aging from the twenties into mature adulthood. Investigating whether serial decline continues into healthy older adulthood would be valuable. Furthermore, that poorer muscle quality as determined by increased MFI affects muscle function when noncontractile tissue replaces muscle fibers is implied. Whether this speculation is true should be investigated with applied research examining function.

CONCLUSION

Lumbar paravertebral muscle fat content increases with aging, in healthy volunteers 3rd to 7th decade of age. Women, low lumbar levels, left side the multifidus muscle are most affected.MR images can be taken as a new tool of investigation to delineate different pathologies and outcome. These can also be taken to compare the natural history and clinical prognosis of the different pathologies, which we can improve it by further study. It can also be used as a protective and preventive tool for the novel targets.

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