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Does lumbar paraspinal muscle fatty degeneration correlate with aerobic index and Oswestry disability index?

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Abstract

Background: We sought to analyze whether the amount of paraspinal fatty degeneration correlates with a patient's physical fitness, and to determine if these findings on lumbar magnetic resonance imaging (MRI) scans can help predict functional outcomes.

Methods: A retrospective review was performed on 172 patients. Inclusion criteria involved being seen by a spine surgeon for low back pain, having aerobic index (AI), body mass index (BMI), Oswestry disability index (ODI), and body fat percentage measured recently, and having had a recent lumbar MRI scan. The percentage of fatty muscle degeneration was graded by three reviewers using T2-weighted axial images at L3 and L5 using a newly proposed system that was validated independently. The system is graded as follows: Grade 1: 0-24%, Grade 2: 25-49%, Grade 3: 50-74%, and Grade 4: 75-100%. An independent *t*-test was used for comparisons.

Results: The average AI was 34.87, and the cohort was divided into two groups: above-average AI (89 patients) and below-average AI (83 patients). For all paraspinal fat measurements and body fat percentage, the difference between the above- and below-average AI groups was statistically significant ($P < 0.05$), with the least amount of paraspinal fatty degeneration and body fat in the greater AI group. Weight alone and BMI were not found to be significantly different between those with above-average AI when compared to those with below-average AI ($P = 0.491$ and $P = 0.122$, respectively). There was a trend for lower ODI scores in the above-average AI group (41.9 vs 46.1), but this did not reach statistical significance between the two groups ($P = 0.075$). For all patients it was shown that there was significantly less paraspinal fat at the L3 level as compared to L5 ($P < 0.001$).

Conclusions: We were able to show that patients with a higher AI have lower body fat percentages and lower amounts of fatty degeneration in their lumbar paraspinal musculature. The amount of paraspinal fatty degeneration, therefore, correlates with physical fitness. Patients with higher AI also showed a trend toward having a lower ODI score.

Key Words: Fatty degeneration, fitness, lumbar spine, magnetic resonance imaging, paraspinal muscle

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INTRODUCTION

Studies have demonstrated an association between paraspinal muscular insufficiency and both the development and persistence of low back pain (LBP).[9,11] Numerous studies have also shown a strong association between poor physical fitness and LBP.[6,11,12,14-16] Few studies, however, have aimed to examine the inter-relationship between various components of physical fitness, fatty degeneration in the lumbar paraspinals, and functional outcomes [Oswestry disability index (ODI)]. We sought to analyze whether the amount of paraspinal fatty degeneration correlates with a patient's measured aerobic index (AI), and to determine if findings of the paraspinal muscles on lumbar magnetic resonance imaging (MRI) scans can help predict functional outcomes. We hypothesize that broad general fitness measures, specifically AI, would be correlated with the degree of fatty degeneration found among the lumbar paraspinal muscles, and that this specific imaging finding would correlate with patient's functional outcomes as measured by ODI.

METHODS

The present study protocol was approved by the institutional review board. The outcome measures used in the correlation analysis were regularly collected data during routine physician and physical therapy visits. Participants were excluded from the study if they had had any previous surgical interventions in their lumbar spine. Inclusion criteria were as follows: age over 18, having had a recent lumbar MRI scan, and having measured ODI scores, body mass index (BMI), percent body fat, and AI recently.

ODI scores were recorded at the initial visit and each subsequent visit that the patient made with the physician. AI was measured using sub-max VO_2 described by Ebbeling *et al*. This submaximal walking test, based on a single stage of a treadmill protocol, provides a valid and time-efficient method for estimating VO_2 max and is validated for an adult population with spine pain.[4] Percent body fat was determined by electrical impedance using the OMRON® fat loss monitor model HBF-306C.

MRI studies were less than a year old and the scans were taken with 1.5 and 3 T magnets. All patient MRIs were reviewed by each of three of the study authors (XXX, YYY, and ZZZ). Each MRI was reviewed using a semi-qualitative scale [Table 1]. MRIs were reviewed using the Image Cast® software program. The sagittal and axial T2-weighted images were reviewed to examine the fat content in the lumbar paraspinal muscles. Using axial views, the fat content in both the right and left paraspinal musculature was measured independently. Measurements were taken at the superior vertebral endplate of each lumbar vertebra. Measurements were initially taken by each examiner independently. Comparative statistics were run to examine inter-rater reliability among the three examiners. Measurements were re-taken as a group consensus only at the superior vertebral endplates of L3 and L5.

There were 172 patients with complete data analyzed, except for one patient for whom age was not recorded. The mean and range of age of our study population were 50 and 17-85 years, respectively. Patients were divided into those with an AI above the average and those with an AI below the average, and patient data were reviewed for differences (mean AI = 34.87). A series of independent sample hypothesis test indicated that there were no significant differences in BMI or weight between the two groups.

Statistical analysis

Several correlations and comparative statistics were run to examine the relationship between AI, BMI, percent body fat, Oswestry scores, age, height, weight, BMI, and our semi-qualitative scale for measuring fatty infiltrate. Correlations were performed using a linear correlation and evaluated based on Pearson correlation coefficients. Hypothesis testing, including analysis of variance (ANOVA), was performed using SPSS version 18 (SPSS Inc. Chicago). A P value of 0.05 was used to determine significance.

RESULTS

All data are presented in Tables 2 and 3. Please see Figure 1 for sample images from the cohort.

Patients with higher AI values were found to have lower paraspinal fat measurements at both L3 and L5 levels, as well as the two scores combined ($P < 0.001$), lower body fat percentages ($P < 0.001$), and were younger ($P < 0.001$). Our statistical test results for ODI differences did approach statistical significance ($P = 0.075$) when examining the difference in functional ability (Oswestry) between the above-average and below-average AI groups [Table 2]. A paired sample hypothesis test of all patients indicated that L3 paraspinal fat was significantly less than L5 paraspinal fat measurements ($P < 0.001$) [Table 3].

Table 1: Grading system of scoring paraspinal fatty degeneration

Grade	Percent fatty degeneration (%)
1	0-24
2	25-49
3	50-74
4	75-100

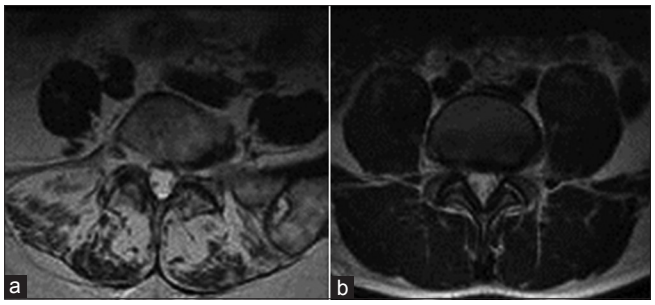

Figure 1: Axial T2 MR images at L5 of two patients from the current study. (a) Demonstration of Grade 4. (b) Demonstration of Grade 1

Table 2: Comparison of parameters in above and below average aerobic index groups

	Above average aerobic index	Below average aerobic index	Delta	*P* value
L3	3.19	4.24	−1.05	0.000
L5	4.33	5.70	−1.37	0.000
L3 and L5	7.52	9.94	−2.42	0.000
% body fat	28.37	34.16	−5.78	0.000
Age (years)	45.39	55.67	−10.28	0.000
ODI score	41.92	46.10	−4.18	0.075

ODI: Oswestry disability index

Table 3: Paraspinal fat measurements at L3 and L5

	L3	L5	Difference	*P* value	L3 and L5 combined
Mean	3.70	4.99	−1.29	0.000	8.69

DISCUSSION

We sought to analyze how a broad general fitness measure is correlated with the degree of fatty degeneration in the lumbar paraspinal musculature and patient-perceived disability (ODI). We were able to demonstrate statistically significant differences in the degree of paraspinal fat and body fat percentage when comparing patients with above-average and below-average AI ($P < 0.0001$). Patients with the highest AI had statistically significant less paraspinal fat at both L3 and L5 levels, as well as the L3 and L5 combined measurement ($P < 0.001$).

Our results also showed a weak, yet statistically significant negative correlation between AI and disability index score. When comparing the aerobic capacity means between the above- and below-average groups, those with higher aerobic capacity scores had lower ODI scores and these results approached statistical significance ($P = 0.075$). Previous works examining the relationship between LBP and imaging findings have primarily focused on non-contractile elements of the spine.[7,13] Other studies have suggested that contractile tissue can be a source of LBP.[2]

Previous investigations have looked at evaluating the cross-sectional area and fatty infiltrate of the lumbar paraspinals. These studies have shown multifidus atrophy in chronic LBP patients.[1,3,10] Kader *et al.* visually analyzed the MRI images of LBP patients and reported multifidus atrophy in 80% of the study patients.[8] The study by Danneels *et al.*, which compared chronic LBP patients with matched healthy subjects, revealed significant differences in muscle cross-sectional area only for the multifidus.[3] Fischer *et al.* have recently shown that various new MRI techniques have the potential to determine fat content of the lumbar paraspinals in patients with LBP.[5]

The strengths of this study are that this is the first study to look at various fitness, functional outcomes, and paraspinal fatty degeneration. The relatively large sample size with complete data is another significant strength. Weaknesses include the retrospective design and lack of homogeneity, which is seen with any clinical population. In addition, the methodology of measuring paraspinal fat was not calculated precisely, and it may be another potential weakness.

In conclusion, our results suggest that patients with higher AI values have lower body fat percentages and lower amounts of paraspinal fatty degeneration in the lumbar spine. As a result, the amount of fatty degeneration correlates with physical fitness, and those patients with higher aerobic capacities show trends toward lower disability scores. Therefore, both aerobic capacity and paraspinal fatty degeneration might be used as objective measures to evaluate and monitor progress in LBP patients. Further studies are necessary to see if paraspinal fatty degeneration is reversible with a concerted exercise program and whether that will influence current and future spinal disability.

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