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The Effect of Physical Activity Level and Body Adiposity on Fatty Infiltration of the Lumbar Multifidus in Apparently Healthy Individuals From an Urban African Setting

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Abstract

Background: Spine stability or core stability exercises are among the most recommended interventions in low back pain management. It is important to clarify whether physical activity and body adiposity affect lumbar muscle multifidus (LMM) among apparently healthy adults.

Objectives: The current study aimed at investigating the effect of physical activity level (PAL) and body adiposity on fatty infiltration of LMM in apparently healthy individuals from an urban African setting.

Methods: Fatty infiltration of LMM was visually graded as normal, slight, and severe using diagnostic ultrasound. Validated Hausa and English versions of IPAQ were employed to analyze PAL, and the bioelectrical impedance analysis machine was used to measure some of the body adiposity parameters and weight.

Results: A slight fatty infiltration of LMM was observed in 40.3% of 196 participants. Slight fatty infiltration of LMM had a higher prevalence in female subjects (39.2%) than males (34.2%). Only two variables of age (P = 0.032; r = 0.153) and visceral fat (P = 0.0001; r = 0.308) had a relationship with fatty infiltration of LMM.

Conclusions: Fatty infiltration of LMM was positively associated with visceral fat and weakly with age among the participants. However, fatty infiltration of LMM had no relationship with the PAL.

Keywords: Lumbar Multifidus, Fat Infiltration, Physical Activity, Body Adiposity, Scanning, Visceral Fat

1. Background

The Global Burden of Disease 2010 Study estimated that low back pain (LBP) is among the top 10 diseases and injuries accounting for the highest number of disability-adjusted life years (DALYs) worldwide (1). According to Bello and Halima (2), the 12-month prevalence of LBP was 32.5%-73.5% in Nigeria.

The role of pathological and symptom variations in paraspinal muscle morphology remains ambiguous. It is reported that patients with chronic LBP have smaller paraspinal muscles (3) and more fatty infiltration than healthy asymptomatic subjects with LBP (4), contradictory with the results of another study (5). A reduction in the cross-sectional area (CSA) and deposition of fat in lumbar multifidus (LM) muscles was observed in patients with unilateral LBP, and these morphological changes were localized to the suspected pathological spinal level and symptomatic side (4, 6); however, the findings were not consistent in all studies (7, 8).

A magnetic resonance imaging (MRI)-based study demonstrated a significant multifidus asymmetry in a group of male patients without LBP (6) and asymptomatic elite athletes (9, 10). Studies on individuals with and without LBP reported atrophy and fatty infiltration of LM (11, 12), all inconsistent. Most of these citations had a small sample size, inadequate qualitative assessment of LM, and lack of examiner blinding (13). Although a high body mass index (BMI) is associated with high fatty infiltration of LM, few studies examined the effect of physical activity and body adiposity on fatty infiltration of LM among the blacks.

2. Objectives

Due to a high prevalence of overweight and obesity among blacks, especially Nigerians (14), the current study aimed at investigating the effect of physical activity level (PAL) and body adiposity on fatty infiltration of LM among apparently healthy black Africans.

3. Methods

The current cross-sectional study employed a disproportionate stratified sampling technique. The study protocol was approved by the Ethics Committee of Kano State Hospital Management Board (ethical code; MOH/OFF/797/TI/1308). Participants who were on medication or treatment for both specific and non-specific LBP, those who received LM training in the past year, individuals undergoing surgery, those with spinal deformities, functional limitations due to medical conditions, or contraindications for ultrasound/sonography were excluded. Informed consent was obtained from the participant. The study sample size was determined based on the cross-sectional study sample size formula (15). With a standard deviation of 1.96 and population proportion of 0.81, based on the previous study (11), the sample size was determined236. However, a total of 196 participants were enrolled in the study (response rate: 83.1%).

3.1. Measurements

The PAL, LM morphology, weight, waist and hip circumferences (WC, HC), and height were measured for all the participants using the international physical activity questionnaire (IPAQ) with validity and reliability with ICC ranging 0.58-0.90 (16), diagnostic ultrasound, Tanita Ironman digital weighing scale (TANITA BC-549 plus IRONMAN^{R}, Tanita Corp., Tokyo, Japan), valid in assessing body weight and adiposity (17), tape measure, and stadiometer (Upsurge Medical Stadiometer ZT-120, England), respectively. The procedures for real-time ultrasound imagery, and reliability, are reported in the literature (Figure 1) (18-20).

3.2. Data Analysis

Descriptive statistics were used to determine the prevalence of fatty infiltration of LM and analyze the demographic characteristics of the participants. For ease of analysis, the age range was categorized into three groups of young (18-35 years), middle-aged (36-65 years), and older (> 66 years) adults. Fat infiltration of the lumbar muscle multifidus (LMM) was visually graded using the standard criteria as follows: normal for estimates of 0%-10% fat, slight for 10%-50% fat, and severe for > 50% fat within the muscle (11). Inferential statistics of paired samples t-test was used to determine the gender difference in the infiltration of LMM. Spearman correlation coefficient was used to determine the association between PAL and lumbar multifidus CSA, and fat infiltration adjustments were made for age, gender, BMI, and the waist-hip ratio. Multiple regression analysis was performed to determine the predictors of infiltration of LMM, followed by hierarchical multiple regression analysis after controlling the sociodemographic (i e, gender, age, and level of education) variables. The sociodemographic and clinical variables were used for regression analysis. All analyses were performed using SPSS version 20.0 at a significance level of $\alpha = 0.05$.

4. Results

A total of 196 participants were enrolled in the current study (response rate: 83.1%), of which 125 (63.8%) were male, 113 (57.7%) married, 106 (55.1%) young adults, 60 (30.6%) employed, and 92 (46.9) attended tertiary education, as shown in Table 1.

The mean ± standard deviation (M ± SD) of BMI, WHR, PAL, and percentages of fatty infiltration, visceral fat, and whole-body fat were 24.40 ± 5.73 kb/m^2, 0.88 ± 0.09, 2652.87 ± 3366.88, 22.24% ± 11.98%, 5.67% ± 4.3%, and 22.23% ± 11.98%, respectively. There were gender differences in BMI ($P < 0.001$), WHR ($P < 0.001$), WC ($P < 0.005$), and percentage of whole-body fat ($P < 0.001$). In addition, 79 (40.3%) subjects had a slight fatty infiltration (male > female) and 180 (91.8%: male>female) a normal visceral fat (Table 2).

There were positive correlations between fatty infiltration of LMM and age (r = 0.237, P = 0.001), level of education (r = 0.197, P = 0.006), and marital status (r = 0.198, P = 0.005). There was a correlation between fatty infiltration of LMM and visceral fat (r= 0.519, P = 0.001) but no correlation between fatty infiltration of LMM and WC (r= 0.091, P = 0.206), WHR (r = 0.095, P = 0.811), percentage of whole-body fat (r = 0.049, P = 0.495), and BMI (r = 0.017, P = 0.811). Though not among the primary objectives of the study, there were negative correlations between PAL and WC (r = -0.299, P = 0.001), WHR (r = -0.143, P = 0.046), percentage of whole-body fat (r = -0.355, P = 0.001) and BMI (r = -0.315, P = 0.001) (Table 3).

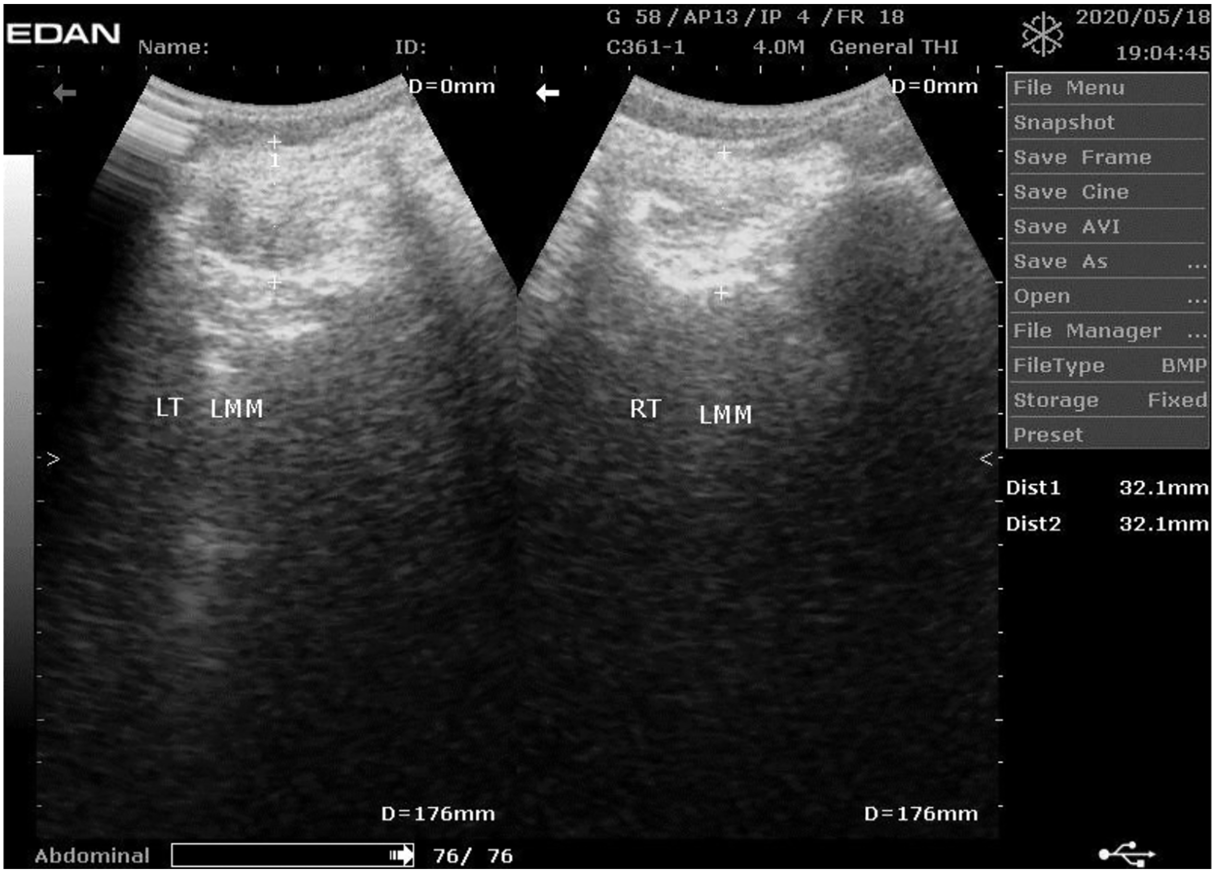

Figure 1. Lumbar Multifidus

4.1. Correlates of Fatty Infiltration of LMM

The result of the linear regression analysis of data showed that the total variance explained by all the variables in the model was 39.3%, F (13,195) = 9.594, R^2 = 40.7%, and P < 0.001, which was significant. In the final model, the contribution of each of the variables making up the model indicated that gender (beta = 0.342, R^2 = 0.015, P = 0.001), age (beta = 0.192, R^2 = 0.038, P = 0.021), level of education (beta = 0.163, R^2 = 0.028, P = 0.016), percentage of whole-body fat (beta = -0.465, R^2 = 0.001, P = 0.010), and visceral fat (beta = 0.540, R^2 = 0.335, P = 0.001) significantly predicted fatty infiltration of LMM. Despite all these, the percentage of visceral fat (beta = 0.557, R^2 = 0.335, P = 0.001), with the largest contribution to the model, was the best predictor of fatty infiltration of LMM in the current study (Table 4). Hierarchical multiple regression analysis was performed by controlling gender, age, and level of education, after the assessment of the normality of variables. Three predictors (gender, age, and level of education) were entered into the first step of hierarchical multiple regression analysis. This model was significant (F (3, 195) = 6.69, P = 0.001)), and the variance explained 95% of the fatty infiltration of LMM. At the end of the second model, the total variance explained by the model as a whole was 38% (F (11,195) = 10.263, P < 0.001)). In the final model, gender (beta = 0.126, P = 0.030), level of education (beta = 0.169, P = 0.014), and visceral fat percentage (beta = 0.540, P < 0.001) made a significant contribution to the model, with a higher beta value for visceral fat (Table 5).

5. Discussion

The current study results showed positive relationships between fatty infiltration of LM and age, level of education, and marital status. A positive relationship was also observed between fatty infiltration of LM and visceral fat. An inverse relationship was found between PAL and WC,

Table 1. Sociodemographic Characteristics of the Participants

	Values[a]
Gender	
Male	125 (63.8)
Female	70 (36.2)
Age, yr	36.2 ± 14.8
Young adult	106 (55.1)
Middle-aged adult	72 (36.7)
Old adult	16 (8.2)
Marital Status	
Married	113 (57.7)
Single	80 (40.8)
Divorce	1 (0.5)
Separated	2 (1.0)
Occupation	
Employed	60 (30.6)
Unemployed	41 (20.9)
Self-employed	93 (47.4)
Retired	2 (1.0)
Educational Level	
No formal education	9 (4.6)
Primary school	15 (7.7)
Secondary school	80 (40.8)
Tertiary education	92 (46.9)

[a]Values are presented as mean ± SD or No. (%).

WHR, percentage of whole-body fat, and BMI. The predictors of fatty infiltration of LMM were age, gender, level of education, and percentages of whole-body fat and visceral fat, while gender, level of education, and percentage of visceral fat were the predictors of fatty infiltration of LMM, and percentage of visceral fat the best predictor. A high prevalence of fatty infiltration is also reported in previous studies on patients with LBP and healthy controls (13). More than half of the participants had a normal fatty infiltration of LMM, with about 40.3% demonstrating high fat infiltration. The majority of the participants had normal or slight fatty infiltration of LMM as no participant fell within the range above 50%, similar to previous studies (11, 13). In the current study, the prevalence of slight fatty infiltration of LM was higher in females than males (39.2% vs. 34.2%); consistent with findings of previous studies (8, 11). It could be concluded that adults with asymptomatic LBP have normal fatty infiltration of LM, unlike those with LBP, and that it is more common in females.

Kjaer et al., (11) reported that age could affect fatty infiltration of LM, and it is more common among older people (13), similar to the findings of the current study. However, no association was reported between anthropometric variables and the CSA of LMM in a study with a small sample size (19). There was a positive relationship between fatty infiltration of LM and the level of education and marital status. To the best of authors' knowledge, there is a lack of studies on the relationship between fatty infiltration of LM and level of education and marital status. Earlier studies showed a relationship between weight gain, educational level, marital status, and fatty infiltration of LM (20, 21).

There was a positive relationship between fatty infiltration of LM and visceral fat, but no relationships with WC, WHR, percentage of whole-body fat, and BMI. Crawford et al., (8) also reported no association between fatty infiltration of LM and BMI, while Menezes-Reis et al., (22) reported an association between it and height, weight, and BMI, contrary to the current study finding. The limitation of the study by Menezes-Reis et al., (22) was in the age group (20-40 years) recruited. The current study showed a positive relationship between visceral fat and fatty infiltration of LM, which to the best of the authors' knowledge, was the first of its kind. Motta et al., (23) reported no relationship between abdominal fat and multifidus fat percentage in males ($r = -0.405$, $P = 0.169$) and females ($r = 0.287$, $P = 0.234$). Their study had few limitations, including the small sample size ($n = 32$) and young adult recruitment. The current study sample size was larger ($n = 196$) and included individuals of 18 years and above.

The majority of the study participants had normal fatty infiltration of LM, with the mean ± SD of 9.83 ± 1.72, which was lower than that of a study from other settings (22). The predictors of fatty infiltration of LM were age, gender, level of education, percentage of whole-body fat, and visceral fat; gender, level of education, and visceral fat were predictors after controlling for certain sociodemographic variables. Individuals with large visceral fat are prone to have fatty infiltration of LM, as observed in the current study, which is in line with previous studies (24, 25).

5.1. Limitations

The current study findings should be interpreted with caution as they do not provide causative factors for LBP. Functional tests should be performed in future studies to assess the PAL of the participants, and more sophis-

Table 2. Clinical Variables of the Participants

	Male, N = 125	Female, N = 70	Mean ± SD	P	Total, N = 196
BMI			24.40 ± 5.73	0.001	
Underweight	17 (13.6)	8 (11.3)			25 (12.8)
Normal weight	70 (56.0)	20 (28.2)			90 (45.9)
Overweight	27 (21.6)	20 (28.2)			47 (24.0)
Obese	11 (8.8)	23 (32.4)			34 (17.3)
WHR			0.88 ± 0.09	0.001	
Low risk	103 (82.4)	20 (28.2)			123 (62.75)
Moderate risk	20 (16.0)	15 (21.1)			35 (17.86)
High risk	2 (1.6)	36 (50.7)			38 (19.39)
PAL			2652.87 ± 3366.88	0.008	
High	45 (23.0%)	20 (10.2%)			65 (33.2)
Moderate	47 (24.0%)	23 (11.7%)			70 (35.7)
Low	34 (17.3%)	27 (14.3%)			61 (31.1)
% Fat Infiltration			9.83 ± 1.72	0.085	
Normal	77 (39.3)	40 (20.4)			117 (59.7)
Slight	48 (24.5)	31 (15.8)			79 (40.3)
WC			84.23 ± 13.42	0.005	
Visceral Fat			5.67 ± 4.3	0.242	
Healthy level	117 (93.6)	63 (88.7)			180 (91.8)
Excess level	8 (6.4)	8 (11.3)			16 (8.2)
% Body Fat			22.24 ± 11.98	0.001	

Abbreviations: BMI, body mass index; WHR, waist-hip ratio; PAL, physical activity level; WC, waist circumference.

ticated equipment, such as MRI/computed tomography scan, should also be used.

5.2. Conclusion

The current study results showed that the majority of participants had normal fatty infiltration of LM, and there were positive relationships between fatty infiltration of LM and age, level of education, marital status, and visceral fat. The presence of visceral fat was the best predictor of fatty infiltration of LM in the study.

Footnotes

Authors' Contribution: Study concept and design: Mukadas Akindele and Musbahu Mahmud Sani; data collection: Musbahu Mahmud Sani, Mukadas Akindele, Musa Yusuf Danbele, and Sarafadeen Raheem; data analysis: Musbahu Mahmud Sani, Mukadas Akindele, and Musa Yusuf Danbele; manuscript drafting: Mukadas Akindele and Musa Yusuf Danbele; critical revision of the manuscript for important intellectual content: Sarafadeen Raheem.

Conflict of Interests: The authors declared no conflicts of interest.

Ethical Approval: The study protocol was approved by the Ethics Committee of Kano State Hospital Management Board (ethical code: MOH/OFF/797/TI/1308).

Funding/Support: There was no funding/support for the study.

Informed Consent: ALL the participants filled and signed an informed consent form after the study objectives were explained to them.

Table 3. The Relationship Between Fatty Infiltration of Lumbar Muscle and Sociodemographic and Anthropometric Variables

	Pal	Age	Gender	Educational Level	Marital Status	Occupational Status	WHR	WC	Visceral Fat	%Body Fat
Age, yr		1								
r	-0.128									
P Value	0.073									
Gender			1							
r	-0.171	0.104								
P Value	0.016	0.148								
Educational Level				1						
r	-0.03	0.002	-0.07							
P Value	0.679	0.981	0.33							
Marital Status					1					
r	-0.122	0.692	0.243	0.037						
P Value	0.09	0	0.001	0.605						
Occupational Status						1				
r	0.113	-0.143	-0.008	-0.462	-0.085					
P Value	0.114	0.045	0.907	0	0.237					
WHR							1			
r	-0.143	0.370	-0.329	0.003	0.264	-0.039				
P Value	0.046	0	0	0.97	0	0.586				
WC								1		
r	-0.299	0.539	0.204	0.076	0.554	-0.161	0.571			
P Value	0	0	0.004	0.293	0	0.024	0			
Visceral Fat									1	
r	-0.002	0.285	0.083	0.042	0.251	-0.075	0.03	0.089		
P Value	0.0975	0	0.246	0.559	0	0.297	0.673	0.216		
% Body Fat										1
r	-0.355	0.449	0.609	0.022	0.492	-0.146	0.138	0.767	0.065	
P Value	0	0	0	0.763	0	0.042	0.053	0	0.363	
Total Fat Infiltration										
r	-0.013	0.237	0.08	0.197	0.198	-0.107	0.095	0.091	0.519	0.049
P Value	0.858	0.001	0.265	0.006	0.005	0.135	0.185	0.206	0	0.495

Abbreviations: PAL = Physical activity level, WHR = waist-hip ratio, WC = waist circumference.

Table 4. Predictors of Fatty Infiltration of Lumbar Multifidus

Dependent Variable	Gender			Age, yr			Level of Education			%Body Fat			Visceral Fat		
	B	95%CI for β	P Value	B	95%CI for β	P Value	B	95%CI for β	P Value	B	95%CI for β	P Value	B	95%CI for β	P Value
Fatty Infiltration of Lumbar Multifidus	1.394	0.582-2.206	0.001	0.029	0.005-0.054	0.021	0.4	0.076-0.724	0.016	-0.076	-0.116	0.01	0.255	0.198-0.312	0.001

Table 5. The Results of Hierarchical Multiple Regression Analysis

	R	R^2	R^2 Change	B	SE	β	*t*
Step 1	0.0308	0.095	0.095				
Gender				0.521	0.282	0.128	1.847
Age				0.033	0.011	0.219	3.146
Level of education				0.527	0.171	0.215	3.076
Step 2	0.617	0.380	0.286				
Gender				0.678	0.311	0.166	0.03
Age				0.019	0.012	0.126	0.118
Level of education				0.414	0.166	0.169	0.014
Marital status				-0.261	0.296	-0.071	0.38
Occupational status				-0.023	0.15	-0.011	0.877
WC				-0.007	0.021	-0.046	0.743
WHR				3.169	2.681	0.11	0.239
Visceral fat				0.247	0.028	0.540	0
BMI				-0.012	0.038	-0.036	0.746
PAL				0.026	0	0	0.997
%body fat				-0.066	0.07	-0.057	0.352

Abbreviations: PAL = physical activity level, WHR = waist-hip ratio, WC = waist circumference, BMI = body mass index.

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