Forensic Medicine and Anatomy Research, 2023, 11, 1-13
https://www.scirp.org/journal/fmar
ISSN Online: 2327-4107
ISSN Print: 2327-4115

Impact of Multifidus Muscle Morphometry on the Clinical Evolution of Chronic Low Back Pain

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How to cite this paper: Mar, N.B., Ndiaye, A., Diop, A.N., Diagne, G.S., Diao, B., Diao, S., Wade, R., Seck, I.D., Garba, K.Y., Thiam, S.A.G., Ndiaye, M., Gaye, M., Sakho, M.G., Ndoye, J.M.N., Diop, M., Ndiaye, A. and Ndiaye, A. (2023) Impact of Multifidus Muscle Morphometry on the Clinical Evolution of Chronic Low Back Pain. *Forensic Medicine and Anatomy Research*, **11**, 1-13.
https://doi.org/10.4236/fmar.2023.111001

Received: November 27, 2022
Accepted: December 28, 2022
Published: January 13, 2023

Abstract

Purpose: The multifidus muscle is an important extensor muscle of the lumbar spine. It plays a major role in the stability and realization of axial rotation movements of the thoraco-lumbar spine. Its atrophy by fatty degeneration would be at the origin of the occurrence of chronic low back pain which constitutes a public health problem in Senegal. Taking into account its anatomy is essential for the etiopathogenic analysis and the treatment of low back pain. The purpose of our work was to investigate the impact of multifidus muscle morphometry on the anatomy-clinical evolution of low back pain. **Material and method:** this was a prospective study over a period of 30 months from November 2019 to May 2022. It involved 100 patients seen in the neurology department of Fann Hospital for chronic low back pain and who had already had a scanner falling within the criteria for low back pain. We used 3D Slicer, SPSS 20, Excel 2016 software to model and analyze the morphometric data of the multifidus muscle after physiotherapy and control lumbar scans. **Results:** The sex ratio was 2.23. The average age of the patients was 45 ± 7 years. On the initial CT scan, according to the Hadar classification, we noted a predominance of grade 2 with 56% in L5/S1, followed by grade 1 with 32% and grade 3 with 14%. In L4/L5, the majority of patients, 67%, had grade 1. A conflicting circumferential disc bulge with the roots predominating in L5/S1 was present in 94% of men (p-value = 0.02). Before physiotherapy, the average volume of the multifidus was 193 mm^3 ± 39, after physiotherapy it was 203 mm^3 ± 42 with a progression rate of 5.2%. Clinically, severe type pain had regressed from 86% before physiotherapy to 0% after physiotherapy (p-value = 0.03). **Conclusion**: Taking into account the morphometry of the multifidus is an essential element in the management of chronic low back pain.

Keywords

Morphometry, Multifidus, Low Back Pain, Physiotherapy

1. Introduction

The multifid muscle forms the second layer of the deep dorsal muscles and occupies all stages of the spine with a more pronounced enlargement at the lumbo-sacral level [1] [2] [3]. Functionally, it is a spine extender especially at the lumbar level. It plays a major role in the stability of the spine and in the axial rotation of the thoracic-lumbar spine in conjunction with the transverse muscle of the abdomen [4]. Recent work has found it to be a contributing factor in the occurrence of common low back pain [4] [5] which is characterized by the heterogeneity of structural abnormalities, changes in underlying functions, personal and environmental factors [5]. The lumbar multifid is the focus of several interventional or observational studies [6] [7] [8]. Work on MRI scans has recently shown that the lumbar multifid is weaker and less voluminous in low back pain patients compared to people with low back pain [7] [9]. Would this involution of the trophicity of the multifidus, materialized by the fatty infiltration, play a role in the achievement of the discovertebral elements during low back pain? If yes, the visualization of his atrophy by ultrasound or other imaging technique, could be a predictor of low back pain [10].

There is little detailed description of this muscle in the anatomical literature, and local data are even rarer. This anatomical ignorance means that the multifidus muscle is a big forgotten in the imaging interpretation rooms but also in rehabilitation and management of low back pain [6], and yet maintaining her anatomy would help improve lower back pain that has become a public health problem in Senegal [11].

The purpose of our work was to investigate the impact of multifidus muscle morphometry on the anatomy-clinical evolution of low back pain.

2. Materiel Et Methode

2.1. Matériel

These were 100 patients targeted after a common low back pain scan. Siemens Somatom 16-detector scanners and its Syngo Acquisition Workspace and General Electric Optima post processing console were used along with statistical tools for correlations as well as 3D SLICER software and two Mac and Dell PCs.

2.2. Method

The criteria for inclusion were: all patients suffering from low back pain and having done a first scan highlighting abnormality that could explain low back pain and reviewed with a control scanner after 10 or 15 sessions of physiotherapy.

The criteria for not including were: patient suffering from low back pain without an initial scanner or with a scanner describing other abnormalities: traumatic, infectious, tumor, malformative or surgical.

After obtaining each patient's free and informed consent, we examined the following parameters:

- socio-demographic data including age, sex and occupation;
- the intensity of lumbar pain before physiotherapy and after physiotherapy;
- the fatty degeneration of the multifidus muscle according to the disc abnormality in L4/L5 and L5/S1 during the diagnostic scanner and then during the control scanner;
- the volume of the multifidus muscle during the diagnostic scanner and then during the control scanner.

The data was entered into Excel 2016 and the analysis was performed by SPSS 2.0. For relational analysis, we performed a Khi-two independence test using the SPSS 2.0 software to see if there is a link between the qualitative variables and a significant relationship if the p-value is 0.05.

The degree of pain was assessed in 4 degrees: very severe, severe, moderate, mild.

The grade of muscular trophicity correlated to fatty degeneration was established according to the classification of GOUTALLIER which is the most frequently cited; it takes into account the morphological aspect of the muscle, it distinguishes 5 grades [12]:

- 0: normal muscle
- 1: muscle with traces of fat
- 2: presence of fat infiltration, but more muscle than fat
- 3: as much muscle as fat
- 4: more fat than muscle

CT images were analyzed using a Syngo Acquisition Workspace post processing console in Bone Window (FO) and Small Parts (PM) with MPR, MIP, and Volume Rendering (VRT) reconstructions.

Using the 3D SLICER software, we modelled the multifidus muscle and determined its volume in cm^3.

Automatic muscle selection does not include fat. The sum of the slices added gives the muscle volume.

Initially, the muscle was segmented slice by slice on axial CT images. In the next step, the three-dimensional muscle volumes were calculated automatically using the program interpolation function. Axial segmentation accuracy was verified using coronal images and sagittal multi planar reconstructions. Segmentation corrections were made using all three dimensions for better accuracy (**Figure 1**).

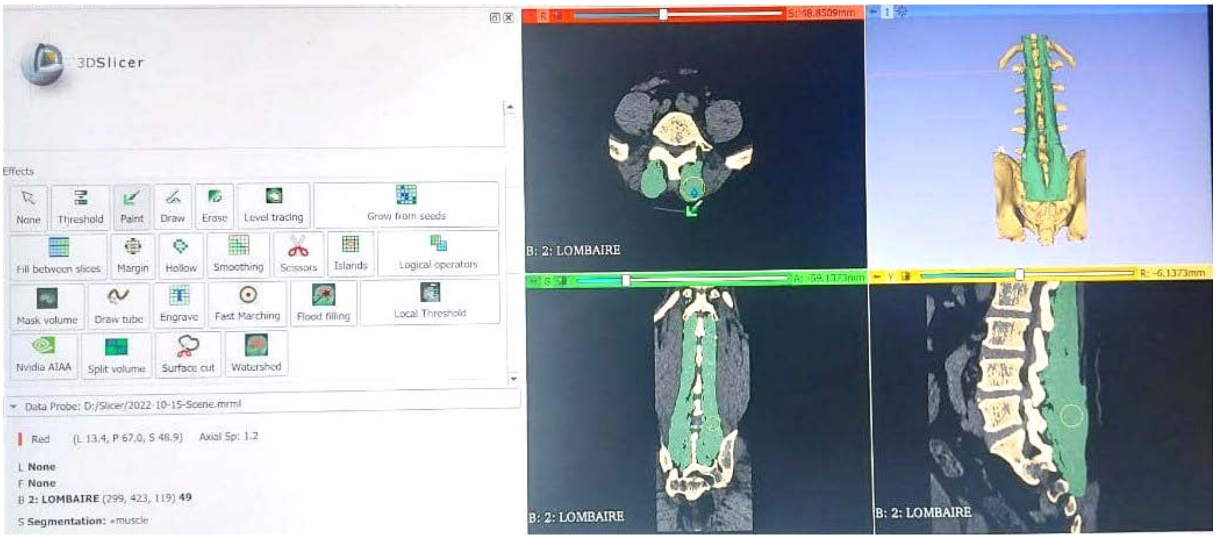


Figure 1. Multifidus muscle segmentation by slice method.

Figure 2 shows the 3D visualization of the volume rendering obtained. This volume rendering isolated the lumbosacral multifidus muscle and its bony hinge as shown in Figure 2(a). Figure 2(b) highlights the image of the lumbar multifidus muscle after detachment from the bony framework.

3. Results

3.1. Age

The study population was divided into four age groups: [30 - 40 years [(25%), [40 - 50 years [(53%), [50 - 60 years [(20%) and [60 - 70 years [(2%). The average age of our patients was 45 years ± 7 with extremes of 32 and 65 years ± 7 with extremes of 32 and 65 years.

3.2. Sex

The sex ratio of our sample was 2.23 with 69 men and 31 women.

3.3. Pain before Physiotherapy

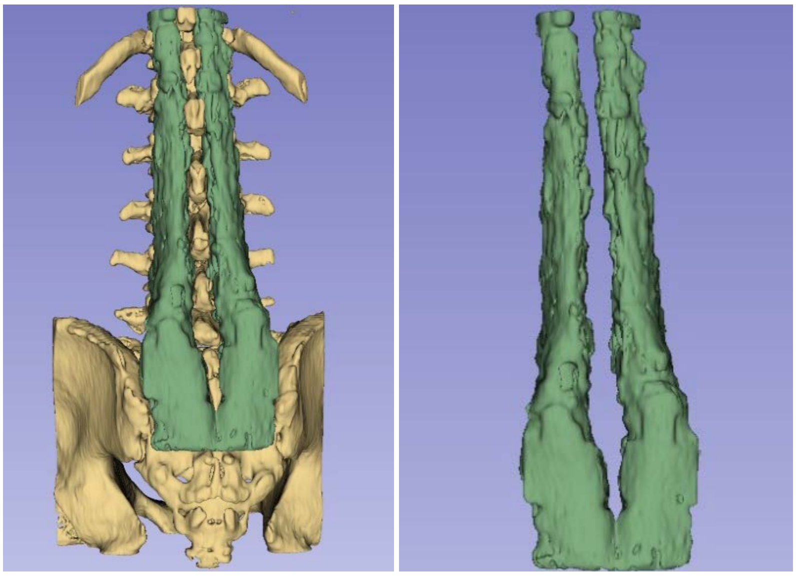
Prior to physiotherapy, 98 % of patients had very severe to severe pain followed by 1% with moderate pain and 1% with mild pain remaining.

3.4. Pain after Physiotherapy

After physiotherapy sessions, 88% of patients no longer had pain, the remaining 12% had mild pain.

3.5. Involution or Muscle Fat Degeneration in L4/L5 Depending on the Disc Abnormality before Physiotherapy

Bilateral grade 1 fatty degeneration of the multifidus muscle in L4/L5 was found in 42% of our patients before physiotherapy and the absence of fatty degeneration concerned 7% of patients.



(a) (b)

Figure 2. (a) Segmented multifidus muscles with lumbar support; (b) Segmented multifidus muscles without lumbar support.

Table 1 reports at the L4/L5 level, the degree of fatty degeneration of the multifidus muscle before physiotherapy sessions according to the disc abnormality encountered: disc bulge (discrete or complete, conflict with the roots) with a p-value of 0.93.

Figure 3 shows a bilateral grade 0 fatty degeneration of the multifidus muscle into L4/L5 associated with a complete circumferential disc bulge, conflicting with the roots.

Figure 4 shows a grade 2 (yellow circle) bilateral fatty degeneration of the multifidus muscle into L4/L5 associated with a complete circumferential disc bulge conflicting with the roots.

3.6. L5/S1 Fatty Degeneration as a Function of Disc Abnormality before Physiotherapy

Bilateral grade 1 fatty degeneration of the multifidus muscle in L5/S1 was found in 54% of our patients before physiotherapy sessions.

Table 2 shows, at the L5/S1 level, the bilateral fatty degeneration grade of the multifid muscle before the strengthening sessions according to the disc abnormality encountered: disc bulge (discrete or complete, conflict with the roots) with a p-value of 0.03.

Figure 5 shows a bilateral grade 1 fatty degeneration of the multifidus muscle into L5/S1 associated with a complete circumferential disc bulge, conflicting with the roots.

3.7. Muscle Fat Degeneration into L4/L5 as a Function of Disc Abnormality after Physiotherapy

An absence of L4/L5 fatty degeneration was found in 49% of patients and 44% of patients were grade 1 bilateral multifidus muscle fatty degeneration. Table 3 details, at the level of L4/L5, the degree of fatty degeneration of the multifidus muscle after physiotherapy sessions according to the disc abnormality encountered: disc bulge (discrete or complete, conflictual with the roots) with a p-value of 0.32.

Table 1. Muscle fat degeneration by type of disc abnormality L4/L5 prior to physiotherapy.

GRADE L4/L5 BEFORE KINESITHERAPY	DEBORD DISCRETE	DEBORD FULL	SET
0: normal	6	1	**7**
1: presence of traces of grease	31	11	**42**
2: more muscle than fat	23	17	**40**
3: as much muscle as fat	3	8	**11**
4: more fat than muscle	0	0	**0**
SET	**63**	**37**	**100**

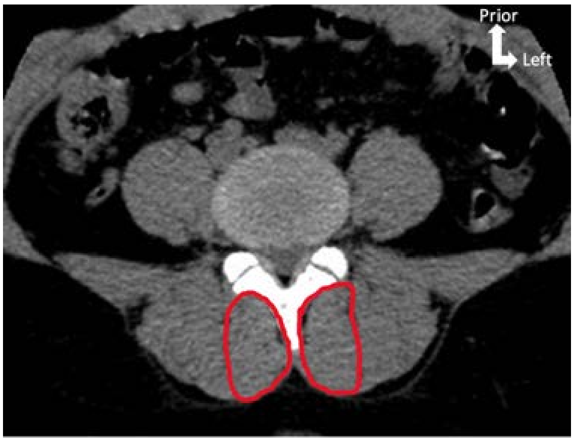


Figure 3. Bilateral fatty infiltration of multifidus muscle Grade 0 in L4/L5.

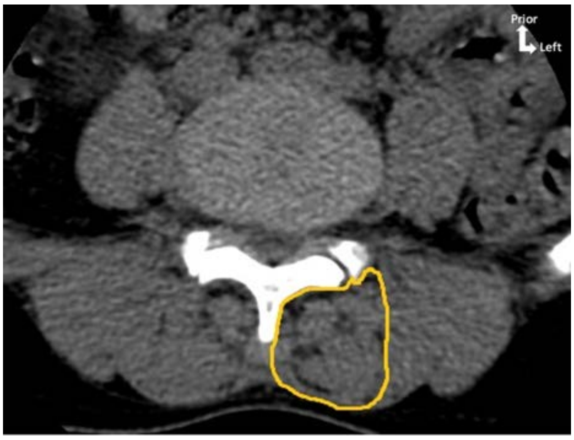


Figure 4. Fatty infiltration of the Grade 1 multifidus muscle into L4/L5.

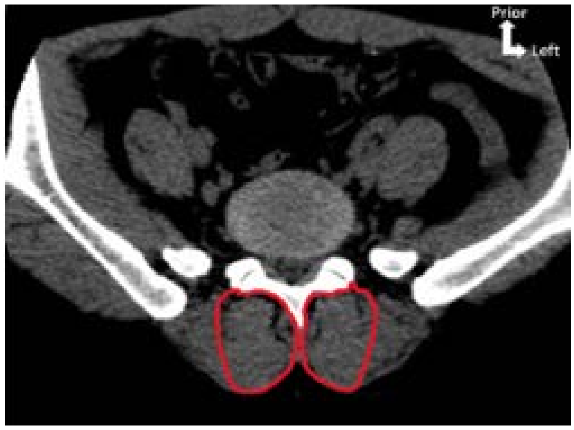


Figure 5. Bilateral Grade 1 fatty infiltration of multifidus muscle into L5/S1.

Table 2. Muscle fat degeneration according to the type of L5/S1 disc abnormality before physiotherapy.

GRADES IN L5/S1 BEFORE KINESITHERAPY	DEBORD DISCRETE	DEBORD FULL	SET
0: normal	7	2	**9**
1: presence of traces of grease	35	19	**54**
2: more muscle than fat	19	15	**34**
3: as much muscle as fat	2	1	**3**
4: more fat than muscle	0	0	**0**
SET	**63**	**37**	**100**

Table 3. Muscle fat degeneration according to the type of disc abnormality L4/L5 after physiotherapy.

GRADE IN L4/L5 AFTER KINESITHERAPY	DEBORD DISCRETE	DEBORD FULL	SET
0: normal	35	14	**49**
1: presence of traces of grease	24	20	**44**
2: more muscle than fat	4	3	**7**
3: as much muscle as fat	0	0	**0**
4: more fat than muscle	0	0	**0**
SET	**63**	**37**	**100**

3.8. L5/S1 Fatty Degeneration as a Function of Disc Abnormality after Physiotherapy

An absence of L5/S1 fatty degeneration was found in 51% of patients and 38% of patients were grade 1 bilateral multifidus muscle fatty degeneration. Table 4 shows, at the L5/S1 level, the degree of fatty degeneration of the multifidus muscle after the physiotherapy sessions according to the disc abnormality encountered: disc bulge (discrete or complete, conflictual with the roots) with a p-value of 0.04.

3.9. Multifidus Muscle Volume

The mean volume of multifidus muscle increased from 193 cm^3 before physiotherapy to 203 cm^3 after physiotherapy. Table 5 summarizes the volumes of multifidus muscle before and after physiotherapy sessions.

3.10. Correlation between Sex and Disc Lesions

The complete discal panel, whether or not associated with a discal void, interested 94.2% of the male population and 77.4% of the female population. There was a significant relationship between sex and disc lesion with a p-value of 0.02.

Table 6 reports disc lesions and their relative percentage by sex.

Table 4. Muscle fat degeneration by type of L5/S1 disc abnormality after physiotherapy.

GRADE IN L5/S1 AFTER KINESITHERAPY	DEBORD DISCRETE	DEBORD FULL	SET
0: normal	37	14	**51**
1: presence of traces of grease	22	16	**38**
2: more muscle than fat	4	7	**11**
3: as much muscle as fat	0	0	**0**
4: more fat than muscle	0	0	**0**
SET	**63**	**37**	**100**

Table 5. Volumes of multifidus before and after physiotherapy sessions.

	Multifid volume before physiotherapy (cm^3)	Multifid volume after physiotherapy (cm^3)	Absolute Deviation	rate of progression
Average	193	203	10	5%
Standard deviation	39	42	3	8%
Median	198	209	11	6%
Minimum	131	122	−9	−7%
Maximum	288	298	10	3%

Table 6. Correlation between sex and disc lesions.

Sex	debord discrete	debord full	set	odds ratio	ic a 95%	p-value
FEMININE	17 (54.8%)	14 (45.2%)	**31 (100%)**	0.21	[0.06 - 0.78]	0.02
MASCULINE	46 (66.6%)	23 (23.3%)	**69 (100%)**			

4. Discussion

According to Hadar [13], imaging is an advantageous way of studying in vivo and non-invasive muscles, it has accessibility and a better perception of fatty atrophy. Our study agrees with the latter's conclusions by showing that CT can be the reference examination in the search for disc degeneration and fatty involution of multifidus muscle. In addition, it is widely used in the identification of back muscles [14]. Indeed, of the 100 patients selected, it allowed to evaluate these two constants. This was the case with Hadar's 1983 study, which combined fat involution and muscle atrophy [13]. DEMOULIN *et al.* who have worked with ultrasound join us because, for them, ultrasound can be used for the study of muscles but it has limits for the measurement of width. It also does not allow an exact measurement of the density and hardly locates the vertebral level with low reproducibility [15]. There is also MRI which is very efficient especially with soft parts that can facilitate many measurements common or not with the scanner. It was used by Kader to change the Hadar classification with an inter-observer correlation of 0.86 to 0.99 versus 0.70 to 0.81 on the scanner [16].

Even if imaging is an attractive means of study for the muscle because of its ease of implementation, commonly performed and reproducible, remember that the characteristics of the muscles in imaging are not perfectly correlated to their strength, and let us not forget the other means of studying the muscles that allow a direct measurement of their strength, possibly more relevant for evaluating the proper functioning of the muscles [12]. GOUTALLIER's study takes into account muscle mass in particular with a limit on the exact quantification of fat [13]. Thus, using 3D SLICER, we were able to calculate muscle volume before and after physiotherapy significantly. This is a software that has the advantage of taking into account several parameters.

After 10 to 15 sessions of kinesia, the p-value remains statistically significant and is 0.04 in L5/S1 and not significant in L4/L5 (0.94 p-value) hence a positive influence of muscle strengthening on the volume.

Other authors such as Fukunaga T [17] conclude that muscle strength is linearly related to the area of physiological section that is obtained from muscle volume divided by fibre length using MRI images. He used the same methods as us on two MRI and CT modalities. Kim and al had [14] reported the measurement reliability and potential benefit of MRI that does not use ionizing radiation and also allows dynamic computation. He has access to his study on the correlation between geniohyoidian and digastric muscle atrophy during dysphagia. Figueiredo and al. [18] join us in strengthening by favoring the training that he considers to be the most effective method to increase muscle mass that has many health benefits. Although it is considered safe and clinically relevant for the treatment and prevention of many of the diseases, however, the majority of available evidence supports a clear dose-response relationship between the resistance training volume in order to obtain an efficient result [16]. However, contrary to the calculation of muscle volume, the literature offers few results.

For fat, Paris Institute of Myology, [19] uses methods based on the chemical shift difference between water and fat protons are currently the reference approaches to quantify and evaluate fat infiltration in muscle tissues with T1 values that are also strongly affected when healthy muscles are replaced chronically by fat. This is often used for diagnostic purposes by classifying T1-weighted images with the Mercury Lamminen scale but also in the 3D slicer which remains a quick method of determining volumes [20].

Similarly, Holzbaur and Al. [20] add that muscle strength-generating properties are often derived from cadaveric studies of muscle architecture. While the clinical application is dynamic hence the interest of using magnetic resonance imaging, they worked on the muscles of the upper limbs and their respective distribution

In our population the average age was 45 years ± 7 and extremes 32 and 65 years. These results are in the same order of magnitude as those found by Cosmin [8] and Kim *et al.* [14] with an average age of 46.2 and 47.2. These two averages are included in the age range [40, 50[. The results of Cherin who worked on a larger sample, go in the same direction with a larger interval ([30 - 64[) including our age group [21].

The average age of onset of relatively advanced low back pain may be explained by a linear increase in the third decade with a peak around age 50 [22]. So low back pain is not normally, the prerogative of the elderly but its frequency its duration and especially the functional disability for which it is responsible increase with age. They are related to the degeneration of spinal structures that begins in the second decade of life but whose intensity is very different from one subject to another [10].

Our male-dominated population with a sex ratio of 2.23 was in agreement with Cherin's, who found a slightly higher sex ratio of 3.88 [21]. This male predominance could be explained by the inadequacy of the working environment vis-à-vis the personal abilities that affect men more in our society as in France. Thus, the male sex seems to be a predisposing factor in the occurrence of multifidus muscle atrophy, indeed there is a relationship between the static and the type of work [22].

Regarding the main functional sign which is pain, our results showed a predominance of the severe intensity type with 86% before physiotherapy. They are similar to those of the literature [7] [9], where the intensity of the pain is found but in different proportions according to its four groups indeed, these symptoms are variable from one patient to another and are not specifically correlated to disc degeneration [14]. However, there is a multitude of differential diagnoses that could correspond to low back pain [17].

So we couldn't make correlation between the severity of the pain and the degree of atrophy of the multifudus muscle, as was the case of some authors like [23].

On the other hand, their etiologies would be represented by a sedentary lifestyle and reduced physical activity, which are often related to the overweight, weakness and atrophy of parasipinaux muci, particularly multifidus [23]. To this must be added an extension of the neurological inhibition of the lumbar multifid muscle following an injury in the lower back where dysfunction is a very common cause [24]. Because of these risk factors, lower back injuries and the incidence and severity of fatty atrophy of the lumbar multifidus muscle tend to be directly correlated with the duration of the symptoms of low back pain. Therefore, it is relevant to strengthen the multifidus muscle in synergy with other deficit muscles in most patients with low back pain. Indeed, to allow an exit from the deconditioning syndrome, it is conceivable to strengthen all the muscles affected by this physical disadaptation [5]. This reinforcement by physiotherapy allowed us an almost total eradication of pain with disappearance of components very severe, severe and average to leave room for only a slight pain for 12% of the population. It was the same with the work of which highlighted the importance of early recovery to act as quickly as possible [25].

Fatty degeneration of the multifudus muscle into L4/L5 was predominant for grade 2 prior to physiotherapy and associated mostly a discrete overhang in 31% of the population. The complete discal debug was 37% also associated with grade 2. There was no statistically significant link p-value 0.93 between these two variables. In contrast to L5/S1, p-value was 0.03 with a statistically significant relationship. These results are consistent with those of Cosmin who used the cross-sectional surface method which is more widely used in for the surface in order to calculate the segmental muscle volume at L4/L5 and L5/S1 [7]. His findings were similar to those found in the literature [13] [25].

5. Conclusion

The mechanism of occurrence of low back pain is intimately related to anatomical dysfunctions of the lumbar region with a particular emphasis on its main extensor and rotator which is the multifidus. Thus, the consideration of multifidus morphometry is an essential element in the management of chronic low back pain.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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