ORIGINAL ARTICLE

Multifidus Atrophy Is Localized and Bilateral in Active Persons With Chronic Unilateral Low Back Pain

George J. Beneck, PhD, PT, Kornelia Kulig, PhD, PT

ABSTRACT. 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.

Objective: To compare the lumbar multifidi muscle volume devoid of fat local to the site of pain in persons with and without chronic unilateral lower lumbar pain.

Design: Prospective cross-sectional design.

Setting: University biokinesiology laboratory.

Participants: Active individuals (n=14) with chronic unilateral lower lumbar pain (>1y) were matched for age, height, weight, and activity level with healthy individuals (n=14). Individuals with back pain had minimal disability (Oswestry Disability Index [mean ± SD], 14.9%±6.3%) at the time of testing.

Interventions: Not applicable.

Main Outcome Measures: Multifidus and erector spinae muscle volumes at the L5-S1 levels, multifidus muscle volumes at the L4 and S2-3 levels.

Results: Average multifidus volume was diminished by 18.1% between groups (P=.026) only at the L5-S1 levels. There was no difference between painful and pain-free sides. There were no volume differences between groups above L5, below S1, or in erector spinae at the L5-S1 levels.

Conclusions: The results of this study indicate that despite a low level of disability and an activity level similar to that of matched control subjects, considerable localized, bilateral multifidus atrophy is present. Such impaired size of the multifidus will likely reduce its capacity to control intersegmental motion, thus increasing the susceptibility to further injury. Unlike acute unilateral low back pain (LBP), muscle size is reduced bilaterally in persons with chronic unilateral LBP.

Key Words: Atrophy; Low back pain; Morphology; Rehabilitation.

BETWEEN 70% AND 80% OF adults experience at least 1 episode of low back pain (LBP) during their lifetime.[1] While most recover within 1 to 3 months,[2] 40% experience a second episode within 6 months.[3] Despite various treatments, many continue to have repeated episodes of LBP several years later.[4] As a result, disability and health care costs are disproportionately higher for individuals with recurrent and chronic LBP than those experiencing their first episode.[5,6]

Laboratory, preclinical, and trial research point to the importance of lumbar muscle performance in spinal health.[7-11] As control and dynamic stability of the trunk are the unique performance demands on lumbar paraspinal muscles, muscle morphology is one of the quantifiable metrics contributing to muscle performance.[12] Impairment of the muscular stabilizing system of the lumbar spine has been related to chronic pain and repeated episodes of LBP.[13,14] The lumbar multifidus, an important component of this muscular stabilizing system, is considered to be a vital stabilizer of the functional spinal units of the lumbar spine. In contrast to other lumbar paraspinal muscles, the physiologic cross-sectional area (CSA) of the lumbar multifidus is more than twice that of either the longissimus thoracis or the iliocostalis lumborum.[15] In vitro studies[16,17] indicate that the multifidus may control intervertebral motion by stiffening the spine. While each of the local paraspinal muscles contributes to spinal stability, the multifidus alone is responsible for more than two thirds of the muscular stiffness in the sagittal plane.[17]

Multifidus atrophy has been reported in individuals with acute LBP,[18,19] chronic LBP,[20] and lumbar disk herniations[21-24] and is associated with poor functional outcomes after disk surgery.[25,26] In addition to atrophy, fat infiltration in the lumbar extensors is a common finding in persons with chronic LBP.[27,28] Fat infiltration in the lumbar extensors is positively associated with LBP,[29] poorer physical performance,[30] and more disability.[28] With pain durations of less than 4 months, multifidus atrophy is specific to the side and segmental region of pain.[18,31] However, it is unclear whether such morphologic atrophy, either unilateral or bilateral, is maintained in active persons with much longer durations of chronic LBP.

There are several limitations in the previous methods used to measure multifidus size. With the use of ultrasound, muscle borders are frequently difficult to define, and fatty infiltrations cannot be distinguished from muscle. Previous studies used a limited number of images representing selected lumbar regions to characterize this multisegmental muscle. Thus, volumetric measurements of muscle, devoid of fat infiltration, would provide a more comprehensive description of the multifidus morphology associated with LBP. Therefore, the purpose of the study was to compare the volume of the multifidus in persons with and without chronic unilateral lower lumbar pain. We hypothesized that the multifidus volume would be reduced

List of Abbreviations

ANOVA	analysis of variance
CSA	cross-sectional area
LBP	low back pain
MR	magnetic resonance

From the Department of Physical Therapy, California State University Long Beach, Long Beach, CA (Beneck); and Division of Biokinesiology and Physical Therapy, University of Southern California, Los Angeles, CA (Kulig).

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Correspondence to George J. Beneck, PhD, PT, Dept of Physical Therapy, ET 122, California State University, Long Beach, 1250 Bellflower Blvd, Long Beach, CA 90840, e-mail: *gbeneck@csulb.edu*. Reprints are not available from the authors.

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specific to the region spanning the lowest 2 functional spinal units in persons with unilateral lower lumbar pain, and that the greatest loss of volume would be on the painful side.

METHODS

Participants

Twenty-eight adults between the ages of 18 and 45 years were recruited for the study. The experimental group consisted of 14 subjects (7 men, 7 women) with a history of chronic LBP. They were matched with a control group without a significant history of LBP. All subjects were recruited from social networks in the Los Angeles area.

Subjects with LBP were recruited to the study if their pain was consistently unilateral and localized between the iliac crest and posterior superior iliac spine with or without referral to the posterior hip region. The first onset of LBP must have occurred at least 1 year before testing, and each subject must have had at least 1 episode of LBP within the last 6 months. Symptoms were minimal or absent for at least 3 days before testing. Control subjects, matched for age (±3y), sex, size, and activity level (table 1), did not have any episodes of LBP for which they sought medical or other care in the last 10 years. Each subject completed a 24-hour Physical Activity Scale to quantify the amount of physical activity during a typical day. The scale has concurrent validity when compared to both an activity diary and accelerometry.[32]

A medical history questionnaire was used to screen each potential subject for the presence of any medical condition that would cause him/her to be excluded from the study. Subjects were excluded if they responded affirmatively to the presence of any of the following: bilateral leg symptoms, polyneuropathy, spinal stenosis, prior low back surgery, structural scoliosis, spondylolisthesis, rheumatic joint disease, urinary or fecal incontinence, diabetes mellitus, spinal malignancy or infection, pregnancy, implanted biological devices that could interact with the magnetic field, claustrophobia, or any condition that the subject identified that might limit participation in physical activity.

Instrumentation and Procedures

Physical screening. The purpose of the physical screen was to characterize each subject's clinical presentation and to clarify consistency with the inclusion criteria. To characterize each subject's low back condition, common clinical examination procedures for patients with LBP were performed including LBP history and screening for radicular symptoms or overt signs of nerve compression. A LBP history was conducted to confirm the location of pain in the lower lumbar spine (ie, L4-5 or L5-S1). Questionnaires were completed to assess the level of disability caused by LBP and to determine the activity level.[32,33] The mean duration of symptoms of the LBP group ± SD was 7.7±5.9 years, and the Oswestry Disability Index was 14.9%±6.3% (minimal disability[33]). All subjects signed a human subject's consent form as approved by the Institutional Review Board of the University of Southern California.

To determine that the origin of pain was from the lower lumbar spine, subjects were asked to point to the location of pain, which was then documented by the investigator on a body diagram. This was followed by active motion tests and manual provocation tests frequently used in clinical examination.[34] Manual pressures (posteroanterior and transverse) applied to the lumbar spinous processes reproduced the subject's description of LBP, and either L4 or L5 was established as the most painful segment in 13 of 14 subjects.[34] One subject reported left-sided pain at the L4-5 level, extending horizontally across the ilium, that was not reproduced with manual pressures. However, she described her symptoms as being aggravated by activities involving flexion, and demonstrated guarding with a reversal of normal lumbopelvic rhythm during active flexion, all considered characteristics of mechanical lumbar pain.[35,36] Two subjects also reported pain below the posterior superior iliac spine inferiorly or inferolaterally, but those symptoms were not reproduced with any sacroiliac provocation tests.[37]

Magnetic resonance imaging: image acquisition. To assess multifidus CSA and volume bilaterally, images from the inferior endplate of L3 to the inferior endplate of S3 were acquired using magnetic resonance (MR) imaging. All MR images were performed at the University of Southern California's Radiology Associates imaging center. Images were taken with the subjects in a supine position and the legs supported such that the hips are flexed to 30°. MR imaging was obtained by a 3.0 Tesla system[a] using T1-weighted images. The MR imaging protocol consisted of a fast spin echo, an echo time of 14.3ms, a repetition time of 600ms, 512 × 512, using a slice thickness of 5mm without an interslice space. The field of view was determined with a sagittal scout image to align axial slices parallel to the L4 inferior vertebral endplate (fig 1). This alignment was chosen because it best approximates a perpendicular orientation to the multifidus fibers that span the L5-S1 region. This region was chosen since it best captures the multifidus morphology as it spans the L4-5 or L5-S1 functional spinal units. These functional spinal units are described as the most common sites of both clinical and pathologic reports of LBP and were identified as the likely source of symptoms in the subjects recruited for this study.[18,29,38-40]

Data Analysis: Image Segmentation

Electronic MR images were imported into Slice-o-matic[b] software program to segment the multifidus CSA devoid of nonmuscle tissue. Each set of images was then coded so as to blind the investigator performing the image segmentation to the subject's group allocation. Gray-scale signal thresholds were determined for each image. To account for a signal intensity gradient resulting from the proximity of the radio frequency coil, each muscle was divided into 6 to 9 regions, on each transverse view. A muscle signal threshold was then determined for each region (fig 2). With the use of the defined muscle signal thresholds, the muscle of the multifidus was segmented to yield a CSA area value for both the right and left multifidi. Volumes for each side were determined by the following formula:

$$\text{Volume} = \text{CSA} \times \text{Slice thickness} \times \text{No. of slices}$$

All images were segmented by the same investigator. The test-retest intraclass correlation (3, 1) reliability coefficient was .961 for CSA and .999 for volume.

The slices used to generate the muscle volumes that represent the musculature spanning the functional spinal units of the painful region (ie, L4-5 and L5-S1) are shown in figure 1. This volume included each slice from the inferior endplate of L4 to

Table 1: Subject Characteristics

Characteristic	LBP (n=14)	Controls (n=14)	*P*
Age (y)	34.0±5.40	32.8±6.10	.699
Height (m)	1.76±0.09	1.69±0.22	.383
Weight (kg)	74.8±18.0	73.7±20.3	.817
PAS (METS)	43.5±10.7	50.3±15.1	.181

NOTE. Values are mean ± SD.
Abbreviations: METS, metabolic equivalents; PAS, Physical Activity Scale.