ACRM
AMERICAN CONGRESS OF REHABILITATION MEDICINE

Archives of Physical Medicine and Rehabilitation

journal homepage: www.archives-pmr.org

Archives of Physical Medicine and Rehabilitation 2014;95:1846-52

ORIGINAL ARTICLE

Morphology Versus Function: The Relationship Between Lumbar Multifidus Intramuscular Adipose Tissue and Muscle Function Among Patients With Low Back Pain

Edward C. Le Cara, DC, PhD,[a] Robin L. Marcus, PT, PhD,[b] Alasdair R. Dempsey, PhD,[c] Martin D. Hoffman, MD,[d,e] Jeffrey J. Hebert, DC, PhD[c]

From the [a]Rocky Mountain University of Health Professions, Provo, UT; [b]Department of Physical Therapy, University of Utah, Salt Lake City, UT; [c]School of Psychology and Exercise Science, Murdoch University, Murdoch, WA, Australia; [d]Department of Physical Medicine and Rehabilitation, Department of Veterans Affairs, Northern California Health Care System, Sacramento, CA; and [e]University of California Davis Medical Center, Sacramento, CA.

Abstract

Objective: To explore the bivariate and multivariate relations between fatty degeneration of the lumbar multifidus muscle (LMM) and LMM function among patients with low back pain (LBP).

Design: Cross-sectional clinical study.

Setting: Hospital.

Participants: Patients with LBP (N=70) referred for lumbar spine magnetic resonance imaging.

Interventions: Not applicable.

Main Outcome Measures: LMM morphology and function were measured at the L4/L5 and L5/S1 spinal levels bilaterally. Quantitative measures of LMM intramuscular adipose tissue (IMAT) were derived from T1-weighted magnetic resonance images. Function was assessed with ultrasound imaging by measuring change in LMM thickness during a submaximal contraction task. The study participants self-reported their level of LBP-related disability (Modified Oswestry Index), pain intensity (numerical pain rating scale), and physical activity (International Physical Activity Questionnaire). Bivariate and multivariate relations between LMM morphology and function were explored with correlational and hierarchical linear regression analyses, respectively. Additionally, we explored for possible covariates with potential to modify the relation between LMM IMAT and function.

Results: There were 70 participants (12 women) enrolled in the study (mean age, 45.4±11.9y). A high level of physical activity was reported by 45.5% of participates. Age, sex, and physical activity level demonstrated variable relations with LMM IMAT and LMM function. There were no significant bivariate or multivariate relations between LMM IMAT and LMM function.

Conclusions: We observed higher levels of physical activity and LMM function and less LMM IMAT than previous studies involving patients with LBP. There was no relation between LMM morphology and function in this cohort of patients with LBP. Issues specific to LMM measurement and recommendations for future research are discussed.

Archives of Physical Medicine and Rehabilitation 2014;95:1846-52

Low back pain (LBP) is one of the most common types of pain reported by patients seeking medical advice. In a 2002 survey of American adults, 26% reported experiencing LBP in the previous 3 months.[1] Consequently, LBP is the most common source of disability worldwide.[2] Moreover, the economic burden of LBP is large, with total cost estimates in the United States ranging from $100 to $200 billion per annum.[3]

Supported by the Chiropractic and Osteopathic College of Australasia (grant no. CR1103) and Murdoch University.

The funding sources had no role in the planning, conduct, or reporting of this study.

This material is the result of work supported with resources and the use of facilities at the VA Northern California Health Care System. The contents reported here do not represent the views of the Department of Veterans Affairs or the United States Government.

Disclosures: none.

0003-9993/14/$36 - see front matter © 2014 by the American Congress of Rehabilitation Medicine
http://dx.doi.org/10.1016/j.apmr.2014.04.019

Attempts to identify underlying causes of LBP using traditional pathoanatomic approaches have been largely unsuccessful,[4-6] and most patients are diagnosed with nonspecific LBP.[4,7] Research focusing on alternative LBP determinants has included measures of lumbar multifidus muscle (LMM) morphology and function.

The LMM is an important spinal stabilizer[8-11] comprising two thirds of the active component of the lower lumbar segmental stability.[12] Recent evidence indicates that fatty degeneration of the LMM is associated with the development of LBP. Compared with asymptomatic individuals, persons with LBP exhibit LMM atrophy and infiltration of intramuscular adipose tissue (IMAT).[13-15] This may result from pain-related disuse, reflex inhibition, and/or muscle denervation.[16,17]

Functional impairments of the LMM are also associated with LBP. Delayed LMM contraction onset[18,19] and decreased muscle activation[20,21] have been observed among individuals with LBP, as have decrements in LMM function after the artificial induction of LBP.[22] Moreover, assessments of LMM function contribute to the clinical assessment of patients with LBP,[23] and LMM function may be associated with clinical outcome after exercise and manual therapy.[24-26]

Research to date has not investigated the relation between LMM morphology and function among individuals with LBP. Therefore, this study aimed to explore for bivariate and multivariate associations between measures of LMM fatty degeneration and LMM function. We hypothesized that increased fatty degeneration would be associated with decreased muscle function.

Methods

Study design

Study participants were recruited from a cohort of consecutive patients referred for a lumbar spine magnetic resonance imaging (MRI) study by their primary care physician at the Veterans Administration Northern California Health Care System. The institutional review boards of the Veterans Administration Northern California Health Care System and Rocky Mountain University of Health Professions approved the study protocol, and all participants provided written informed consent prior to study enrollment.

Participants

We included patients between the ages of 18 and 60 years with current LBP who were referred for a lumbar spine MRI study. LBP was defined as pain in the region between the lower ribs and gluteal folds.[27] Potential participants were excluded if their LBP resulted from serious pathology (eg, tumor, infection, cauda equina syndrome); they had ever undergone lumbar spine surgery or abdominal surgery in the previous 12 months; or they had reported a history of medial branch blocks, radiofrequency denervation, systemic neurologic disease, or current pregnancy.

List of abbreviations:

IMAT intramuscular adipose tissue
IPAQ International Physical Activity Questionnaire
LBP low back pain
LMM lumbar multifidus muscle
MRI magnetic resonance imaging

Procedures

After confirming eligibility and obtaining consent, we collected demographic and clinical information, and participants completed self-report measures of LBP intensity, pain-related disability, and physical activity. Each participant underwent a physical examination that included measures of height, weight, and waist circumference.[28] In addition, the participant's medical records were examined to determine if they had a diagnosis of prediabetes or type 1 or type 2 diabetes.

Self-report measures

LBP intensity was measured with the numerical pain rating scale. Participants rated the intensity of their pain on a scale from 0 to 10, with 0 representing the absence of pain and 10 representing the worst pain imaginable. The patients reported their pain intensity at the time of data collection and their highest and lowest pain levels over the past 24 hours.[29-31] Pain intensity was estimated as the average of the 3 scores. The numerical pain rating scale has been demonstrated to have good reliability, responsiveness, and criterion validity.[30]

We used the Modified Oswestry Disability Index[27] to measure LBP-related disability. Potential scores range from 0 to 100, with higher scores indicating greater disability. This questionnaire has previously demonstrated good levels of test-retest reliability and responsiveness.[32,33]

Physical activity was measured with the long-form International Physical Activity Questionnaire (IPAQ). The IPAQ assesses moderate and vigorous physical activity in 4 life domains: job-related work done outside the home, house and yard work, recreation, and transportation. The questionnaire includes separate measures of time spent sitting at a desk, visiting friends, reading, or watching television. The physical activity outcomes are categorized as low, moderate, or high. The IPAQ has been shown to be both a reliable and valid indicator of physical activity.[34]

MRI assessment of lumbar multifidus morphology

Axial T1-weighted images from the participants' lumbar spine MRI were assessed to quantify LMM fatty degeneration at the L4/L5 and L5/S1 levels bilaterally. The facet joints were used to identify the respective levels to ensure consistency with the ultrasound imaging measure of LMM function. MRI images were collected on a 3.0-T Siemens Verio MRI scanner[a] using a standard phased-array body coil with 4-mm slice thickness, 180-mm^2 field of view, and a 256 × 256 matrix. The images were transferred to a desktop computer and measured using custom-written image analysis software.[b]

For each image, a computer mouse was used to manually trace the region of interest for the LMM on each side and level. The software then calculated histograms representing the frequencies and intensities for all pixels within the regions of interest, allowing separate tissue components to be quantified based on their pixel signal intensity. Similar analyses have demonstrated high levels of intrarater reliability,[35-37] test-retest reliability,[36,37] and concurrent validity when compared with phantom imaging.[35]

Ultrasound measures of lumbar multifidus function

LMM function was measured on the same day as the MRI study by an examiner blinded to the MRI results. We used ultrasound imaging to measure LMM function using methods described