Journal of Bodywork & Movement Therapies (2016) 20, 388–396

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/jbmt

FASCIA SCIENCE AND CLINICAL APPLICATIONS: ORIGINAL RESEARCH STUDY

Stiffness of resting lumbar myofascia in healthy young subjects quantified using a handheld myotonometer and concurrently with surface electromyography monitoring

Kalyani Nair, PhD [a], Alfonse T. Masi, MD, DR.PH [b,*], Brian J. Andonian, MD [b], Alexander J. Barry, BS [a], Brandon A. Coates, BS [a], John Dougherty, BS [a], Emily Schaefer, BS [a], Jacqueline Henderson, PhD [a], Joseph Kelly, PT, MS [c]

[a] *Mechanical Engineering, Bradley University, Peoria, IL 61625, USA*
[b] *University of Illinois College of Medicine, Peoria, IL 61656, USA*
[c] *Department of Physical Therapy, Bradley University, Peoria, IL 61625, USA*

Received 26 October 2015; received in revised form 12 November 2015; accepted 9 December 2015

KEYWORDS
MyotonPro;
Biomechanics;
Lumbar;
Myofascial stiffness;
Passive property;
Surface electromyography

Summary This study aimed to non-invasively quantify passive stiffness of superficial myofascia at a lower lumbar (L3-L4) anatomical level in young healthy male and female subjects and investigate its possible morphological variation. Resting prone lumbar myofascial measurements were quantified using MyotonPro® and statistically analyzed in 20 young healthy individuals over 3-weekly intervals, concurrently with surface electromyography (sEMG). Averaged mean ± SE stiffness (Newton/meter) over three weeks was significantly ($p < 0.001$) greater in males (247.8 ± 11.3) than females (208.4 ± 11.3), on the right (237.7 ± 12.8) than left sides (218.5 ± 12.3), at 10-min (231.4 ± 9.1) than initial baseline (224.8 ± 9.1) values. A polymorphism of stiffness values in 10 male and 10 female subjects was suggested by box plot analyses of the 3 weekly measurements and greater inter-individual than intra-individual variances. Greater knowledge of lumbar myofascial stiffness can improve understanding of their

Abbreviations: Ankylosing spondylitis, AS; Body mass index, BMI; Central nervous system, CNS; Fast Fourier Transform, FFT; Human resting muscle tone, HRMT; Intraclass correlation coefficient, ICC; Low back pain, LBP; Short-range elastic component, SREC; Standard error, SE; Surface electromyography, sEMG.

* Corresponding author. Tel.: +1 309 671 8428; fax: +1 309 671 8513.
E-mail addresses: knair@bradley.edu (K. Nair), amasi@uic.edu (A.T. Masi), bandon2@uicomp.uic.edu (B.J. Andonian), abarry@mail.bradley.edu (A.J. Barry), bcoates@mail.bradley.edu (B.A. Coates), jpdougherty@mail.bradley.edu (J. Dougherty), eschaefer@mail.bradley.edu (E. Schaefer), jhenderson@bradley.edu (J. Henderson), jpkelly@bradley.edu (J. Kelly).

http://dx.doi.org/10.1016/j.jbmt.2015.12.005

contributions in health and chronic low back disorders.

Introduction

Tissue stiffness is an intrinsic material property that can be defined as resistance to deformation from an applied force (Pal, 2014). Clinically, myofascial stiffness or tone incorporates the *resting* material property as well as *activated* myofilamentous contractile physiological component (Masi et al., 2010; Mense and Masi, 2010). The passive resting viscoelastic material property of muscle is independent of central nervous system (CNS) and electromyographic (EMG) activity (Mense and Masi, 2010; Simons and Mense, 1998). The CNS-activated contractile tension is markedly greater than the resting state and can be detected by EMG activity (Masi and Hannon, 2008). The contractile component of muscle is superimposed upon the intrinsic passive material properties (Levin, 2009; Masi et al., 2009). Of note, the experimentally excised passive resting tension of elongated myofascia following an applied extending force has two phases: (1) an initial linear elastic relation over small magnitudes of stretch, and (2) a dynamic, non-linear viscoelastic segment at greater magnitudes of strain (Levin, 2009; Masi et al., 2009). In living subjects, no previous report to our knowledge has quantified the material properties of resting lumbar myofascia. This study analyzes the passive resting stiffness of lower lumbar extensor myofascia in young, healthy subjects using a reliable handheld myotonometer.

Published research on myofascia has focused almost entirely on the active contractile or dynamic states. Currently, dynamometers or other methods are used to measure macroscale stiffness of an entire muscle group (Broberg and Grimby, 1982; Firoozbakhsh et al., 1993; Caligiuri, 1994; Engsberg et al., 1996; Lamontagne et al., 1997; Lee et al., 2004; Gurfinkel et al., 2006). These methods are commonly used to quantify active tension in the muscle group and do not differentiate the passive CNS-independent component from the added active contraction. Multiple investigators have expressed the need for more specific methods to measure passive resting stiffness of a defined myofascial area (Bizzini and Mannion, 2003; Zinder and Padua, 2010; Aird et al., 2012; Marusiak et al., 2012; Bailey et al., 2013; Dougherty et al., 2013).

Clinically quantifiable stiffness represents an assessment tool of high value in rehabilitation of low back pain syndromes (Resnik and Dobrykowski, 2005). Multiple outcome measures are reported in the clinical assessment of low back pain, but none have been shown to be responsive to change within a treatment administration time frame (Resnik and Dobrykowski, 2005). Real time quantitative measurement of myofascial stiffness can assist diagnosis and patient-directed intervention (Maher et al., 2013). The potential for future investigations of a possible polymorphism of human resting muscle tone is promising. If confirmed, the clinical application of this theory to conservative care may create more effective and earlier treatment strategies.

The MyotonPro® (Myoton AS, Tallinn, Estonia) is a non-invasive device capable of quantifying stiffness (tone), frequency (resting tension), and decrement (elasticity) of myofascial tissue (Bizzini and Mannion, 2003; Zinder and Padua, 2010; Aird et al., 2012; Marusiak et al., 2010, 2011, 2012; Bailey et al., 2013; Dougherty et al., 2013). Reliability of the device in measuring voluntarily relaxed muscles had been reported as an intraclass correlation coefficient (ICC) of 0.80 or greater, using the biceps femoris, gastrocnemius (lateral and medial heads), quadriceps femoris, rectus femoris, and vastus lateralis (Bizzini and Mannion, 2003; Zinder and Padua, 2010; Aird et al., 2012; Bailey et al., 2013). The ICC is a descriptive statistic which describes how strongly measurements in the same class or group match each other. To our knowledge, no sequential measurements were reported of individual's lumbar extensor myofascia nor with simultaneous EMG monitoring performed to support a maximally-relaxed resting state in the tested subjects.

MyotonPro® was used previously in research studies to quantify a difference in active contraction of extremity muscle stiffness between male and female subjects. Men generated significantly higher rectus femoris stiffness values, of about one third extent than women at each of five levels of contraction (Zinder and Padua, 2010). However, with respect to passive lumbar muscle stiffness, measurements have not been reported in women vs. men. The MyotonPro® has also been used in studies of pathological muscle conditions, such as Parkinson's disease. The arm biceps, brachioradialis, and triceps muscles had significantly lower stiffness, of about ten percent, on vs. off therapy (Marusiak et al., 2012). In sub-acute stroke patients, the stiffness measurements by the Myoton-3 on extensor digitorum, flexor carpi radialis, and flexor carpi ulnaris showed very high test-retest reliability (ICC = 0.90–0.94) on the affected side, and lesser, but high repeatability (ICC = 0.86–0.92) on the unaffected side (Chuang et al., 2012a; Chuang et al., 2012b). Passive resting lumbar myofascial material properties have a fundamental role in postural equilibrium stability (Masi and Hannon, 2008). Postural stability can be maintained in balanced equilibrium positions by the passive resting lumbar myofascial tone without sEMG evidence of CNS activation, which is economically efficient in energy expenditure.

A critical problem in interpretation of clinical studies of human resting muscle tone (HRMT) has been differentiation of the static, passive condition from any additional low-level tension contributed by CNS-activated contractions (Masi et al., 2009; Gurfinkel et al., 2006; Masi and Hannon, 2008). The knowledge gap applies particularly to passive material properties and their role in the stabilization of the spine. Our group recently reported on greater resting