Journal of Electromyography and Kinesiology 25 (2015) 928–936

Contents lists available at ScienceDirect

Journal of Electromyography and Kinesiology

journal homepage: www.elsevier.com/locate/jelekin

Back muscle fatigue of younger and older adults with and without chronic low back pain using two protocols: A case-control study ☆

Rubens A. da Silva [a,b,*], Edgar R. Vieira [c], Marcos Cabrera [d], Leandro R. Altimari [d], Andreo F. Aguiar [a,b], Alexandre H. Nowotny [a,b], Adriana F. Carvalho [a,b], Marcio R. Oliveira [a,b]

[a] Center for Health Science Research, Laboratory of Functional Evaluation and Human Motor Performance (LAFUP), Universidade Norte do Paraná (UNOPAR), 675 Paris Av, Londrina, PR, Brazil
[b] Doctoral and Masters Program in Rehabilitation Sciences UEL/UNOPAR, 675 Paris Av, Londrina, PR, Brazil
[c] Florida International University (FIU), Physical Therapy & Neuroscience Departments, Wertheims' Colleges of Nursing and Health Sciences & Medicine, 11200 SW 8th St., AHC3-430, Miami, FL, USA
[d] Universidade Estadual de Londrina (UEL), Rod. Celso Garcia Cid, 445 Km 380, Campus Universitário Londrina, PR, Brazil

ARTICLE INFO

Article history:
Received 5 August 2015
Received in revised form 24 September 2015
Accepted 7 October 2015

Keywords:
EMG
Muscle fatigue
Low back pain
Aging

ABSTRACT

The purpose of this study was to compare back muscle fatigue of younger and older participants with and without chronic low back pain (CLBP). Twenty participants without and 20 with nonspecific CLBP participated in this study. Each group contained 10 younger (50% males; mean age: 31 ± 6 yrs) and 10 older adults (50% males; age mean: 71 ± 7 yrs). Two isometric fatigue protocols were presented randomly: (1) to maintain the unsupported trunk at the horizontal position while on a 45° Roman chair for a minute, and (2) to maintain a 10% of body weight box close to the trunk in the upright position for a minute. Surface electromyography (EMG) signals from the back (multifidus and iliocostalis) and one hip (biceps femoris) muscles were recorded bilaterally, and the median frequency fatigue estimate from linear regression slopes of the EMG time-series was computed. There were no significant ($P > 0.05$) age effects, and group-by-age interaction in both isometric and functional fatigue tasks. However, the CLBP groups (both younger and old) displayed more back fatigue than people without CLBP in both fatigue protocols ($P < 0.01$; effect size varying of $d = 0.17–0.32$). This study was sensitive to discriminate that individuals with CLBP did present significantly more pronounced EMG back fatigue than people without CLBP, in both younger and older adults. These results have significant clinical implications for low back pain rehabilitation programs with regard to endurance assessment in both younger and older.

1. Introduction

Poor back muscle endurance has been associated with chronic low back pain (CLBP) (Biering-Sorensen, 1984; Enthoven et al., 2003). The excessive fatigue of back muscles in subjects with CLBP may be associated with a shift in muscle fiber proportion toward type II fibers and a reciprocal atrophy of lumbar muscles (Hides et al., 1994; Mannion et al., 2000). Trunk muscle fatigue may increase neuromuscular deficits, resulting in brief uncontrolled intervertebral movements and consequently may also increase spine instability resulting in tissue strain and in turn a cumulative effect of CLBP (Granata and Gottipati, 2008; Panjabi, 1992).

Aging also results in neuromuscular changes, such as decreased force generation capacity, altered muscle fiber-type proportion, and slower motor unit firing rate. Consequently, this contributes to weaker, less fatigue resilient muscles and increased rate of falls in older adults (Avin and Law, 2012; Dionne et al., 2006; Leboeuf-Yde et al., 2009; Rogers and Evans, 1993; Dutta, 1997; Doherty, 2003). The combination of CLBP and aging effects may help to explain why up to 84% of older adults suffer from back pain (Dionne et al., 2006; Leboeuf-Yde et al., 2009). Given the high prevalence of CLBP, understanding fatigue responses of younger and older adults with and without CLBP is important for the management and prevention of these disorders. Few studies have, however, compared the effects of back pain on muscle fatigue between younger and older adults.

☆ Institute in which the study was conducted: Center for Health Science Research/LAFUP, Universidade Norte do Paraná (UNOPAR), 675 Paris Av, Londrina, PR CEP 86041-120, Brazil.

* Corresponding author at: Laboratory of Functional Evaluation and Human Motor Performance (LAFUP), Universidade Norte do Paraná (UNOPAR), 675 Paris Av, Londrina, PR CEP 86041-120, Brazil. Tel.: +55 (43) 3371 7700x7990; fax: +55 (43) 3371 7721.
E-mail address: rubens@unopar.br (R.A. da Silva).

http://dx.doi.org/10.1016/j.jelekin.2015.10.003
1050-6411/

Fatigue can be measured by the rate of decline of the median frequency (MF) of the muscle firing rate observed using surface electromyography (EMG) (Arab and Salavati, 2007; da Silva et al., 2005, 2008; Larivière et al., 2011; Moreau et al., 2001; Kankaanpaa et al., 1998). The rate of decline of EMG-MF is a valid and reliable index of muscle fatigue during isometric and dynamic contractions (for the latter, when well controlled by slow motion velocity from a context where the EMG signal is not stationary) (Singh et al., 2011a; Biedermann et al., 1991; Larivière et al., 2002; da Silva et al., 2008, 2005). The muscle fatigue-induced decrease in spectral indices has been related to the action potential conduction velocity propagation, which is believed to be a result of metabolic by-product accumulation, such as lactate and extracellular K+ (Brody et al., 1991; Hagg, 1992). EMG-MF has been suggested to be the most suitable parameter for measuring EMG spectral shifts toward lower frequencies, where MF is less sensitive to noise and more sensitive to muscle-fatigue-related physiological changes (especially action potential conduction velocity decreases) during sustained and dynamic contractions (Moritani et al., 1986; De Luca, 1993). This physiological tool could thus be of interest for comparison between old and younger individuals with and without CLBP.

Several fatiguing protocols have been used to measure back fatigue in people with and without CLBP (Arab and Salavati, 2007; da Silva et al., 2005, 2008; Larivière et al., 2011; Moreau et al., 2001; Kankaanpaa et al., 1998). One protocol that is easy to perform is a prone back extension exercise on a Roman chair (Arab and Salavati, 2007; Larivière et al., 2011; Clark et al., 2003) or on an examination table – the Sorensen test (Biering-Sorensen, 1984; da Silva et al., 2005; Kankaanpaa et al., 1998). With the classical protocol, the participant lies on the examining table (or Roman chair) in the prone position with the upper edge of the iliac crests aligned with the edge of the table (Moreau et al., 2001). The lower body can be fixed to the table by three straps (not in a Roman chair), located around the pelvis, knees, and ankles. With the arms folded across the chest, the participant is asked to isometrically maintain the upper body in a horizontal position (Moreau et al., 2001). Overall, the time during which the participant keeps the upper body straight and horizontal is recorded, and for those who experience no difficulty in holding the position, the test is stopped after 240 s. This test in parallel can be measured by EMG estimates as a MF index (Kankaanpaa et al., 1998; da Silva et al., 2005; Champagne et al., 2009).

On the other hand, most studies have only compared older and younger individuals with this type of exercise, evaluating only a healthy sample and using the endurance time variable as the main outcome (Champagne et al., 2009; Parreira et al., 2014) A few other studies assessed muscle fatigue based on EMG techniques, particularly in older adults (Singh et al., 2011a). Furthermore, no study generalized this comparison for tasks representing the workplace and occupational conditions (prolonged static postures, lifting, trunk flexion, repetitive movements), which often expose workers to risk factors for musculoskeletal disorders such as back pain (da Costa and Vieira, 2010; Pope et al., 2002; Vieira and Kumar, 2004). The present study introduced a functional protocol related to workplace activity of the trunk muscles that would be of interest for this comparison (Bonato et al., 2002): a sustained upright posture task with a box-load at 10% of total body mass, to be safe for individuals with and without CLBP (Han et al., 2013), which is also often used during activities of daily living.

The purpose of this study was to compare back muscle fatigue of younger and older subjects with and without CLBP using two isometric fatigue protocols through EMG measurements: (1) to maintain the unsupported trunk in a horizontal position while on a 45° Roman chair for one minute, and (2) to maintain a 10% of body weight box close to the trunk in the upright position for one minute. First, we hypothesized that individuals with CLBP would present a higher rate of back fatigue than individuals without CLBP during a classical unsupported trunk protocol on a Roman chair. Second, we hypothesized that the results could be generalized for the functional protocol of standing and maintaining a box-weight. Finally, we hypothesized that older participants with CLBP would present poor endurance by EMG measurement compared to those without CLBP.

2. Methods

2.1. Subjects

Twenty participants with and 20 without non-specific CLBP (CLBP vs. WCLBP), which can be defined as multifactorial and/or mechanical physical back problems (Panjabi, 1992), were recruited on a voluntary basis from January to September 2014 at the Universities in Londrina City in Brazil (students/workers between 18 and 45 yrs old) and older adults (above 60 yrs old from the local community). Both groups were matched by age and sex (50% males and 50% females). We used data from a previous study to estimate the sample size needed to identify differences in back fatigue between people with and without CLBP (Singh et al., 2011a). Based on the mean values of the main EMG-MF parameter (median frequency from power spectral) of older (30 ± 4% total of power) and younger adults (25 ± 4%), 10 participants would be needed per group to run an unpaired *t*-test (95% CI) between groups with a power of 0.80.

The participants were informed about the study's experimental protocol and potential risks and written consent was obtained before their participation. The protocol and the consent forms were previously approved by the local ethics committee (#250.551). During the initial evaluation, participants were asked by a trained physiotherapist (MRO) about medical history, back and hip symptoms and CLBP history. The inclusion criteria for the CLBP group were: history of lumbar or lumbosacral pain with or without proximal radicular pain and presence of chronic pain defined as daily or almost daily pain for a minimum of 3 months. The inclusion criteria for the WCLBP group were: no history of CLBP (defined as an episode that required treatment or led to missed work or school days). The exclusion criteria for both groups were: sensory or neurological disorders, previous back surgery, active lower limb musculoskeletal pathology, falls in the past year, Mini-Mental State Examination score <21 (Hughes et al., 1996), being enrolled in any physical activity program (>3 days a week) at the time of the study or a rehabilitation program for the previous 12 months before the start of the study.

2.2. Procedures

Data collection was completed in one session of approximately 2 h in the same laboratory for all tests. All procedures were carried out in the morning (time 8:00–12:00) in a quiet laboratory room with controlled indoor temperature (22 °C) and light intensity. The same investigator performed all the procedures and tasks with the participants to ensure uniformity. Before testing, individuals with CLBP completed the Portuguese versions of the questionnaires:

1. The Rolland–Morris disability questionnaire (RDQ) – score range: 0 = no disability to 24 = severe disability (Nusbaum et al., 2001).
2. The Fear-Avoidance Beliefs Questionnaires for physical activities (FABQp) – score range: 0–24 with higher scores meaning more fear (Abreu et al., 2008).