ISB 2013 BRAZIL
XXIV CONGRESS OF THE INTERNATIONAL SOCIETY OF BIOMECHANICS
XV BRAZILIAN CONGRESS OF BIOMECHANICS

ANALYSIS OF THE ELECTROMYOGRAPHIC FATIGUE THRESHOLD OF THE ERECTOR SPINAE MUSCLES IN INDIVIDUALS WITH CHRONIC LOW BACK PAIN

Maria Simone T. Barreto, Ligia M. Pereira, Bruno F. Mazuquin, Karen Obara, Josilainne M. Dias, Fernanda Q.R.C. Mostagi and Jefferson R. Cardoso
Laboratory of Biomechanics and Clinical Epidemiology, PAIFIT Research Group, Universidade Estadual de Londrina
email: paifit.uel@gmail.com

SUMMARY
Low back pain is a cause of functional limitations among individuals. Previous studies have demonstrated that subjects with low back pain have a reduction in strength and endurance of the erector spinae muscles and also low resistance to fatigue. The electromyography fatigue threshold (EMG_{FT}) is an important method for demonstrating the endurance of a specific muscle.
The aim of this study was to estimate the EMG_{FT} of the erector spinae muscle in individuals with chronic low back pain, through surface electromyography during trunk extension tests in the sitting position. The study included 10 volunteers who initially performed the maximal voluntary isometric contraction (MVIC) test, and afterwards the fatigue tests at 30, 50 and 75% of MVIC. It was not possible to determine the electromyographic fatigue threshold of the participants. One of the most likely causes of this finding would be the nonlinearity of the electromyographic parameters.

INTRODUCTION
Low back pain can affect 80% of individuals and has become the main cause of functional limitation among subjects of less than 45 years of age [1]. Surface electromyography is an important tool used to measure the electrical activity in muscles [2]. Fatigue is characterized as a failure or decline in muscle strength during support or repeat activities and this concept is applied to monitor or measure the deficit in muscle performance during an activity [3]. The EMG_{FT} is an indicator of the endurance, thus, its determination and monitoring becomes critical for predicting the activity of a muscle [4].

METHODS
The study included 10 volunteers with non-specific chronic low back pain, of which seven were female, with a mean age of 35.2 years (SD = 9.1) and body mass index (BMI) of 26.3 kg/m^2 (SD = 4.8) Subjects with non-specific chronic LBP were defined as individuals who reported pain in the area between the inferior-most aspect of the scapula and the gluteal folds, with or without radiation to the lower extremities. Pain and disability were measured by both the Visual Analogue Scale (VAS) and a self-reported score from the Brazilian Quebec Back Pain Questionnaire. Each of the volunteers signed a consent form (Ethical Committee #062/2011).

For data acquisition, a 16-channel EMG system (MP150, BIOPAC System, USA) with two amplifiers with an impedance of 2 MΩ, common mode rejection ratio of 1000 MΩ, signal adjusted to 2000 samples per second and band pass filtered in 20 to 450 Hz was used. Bipolar active electrodes of 13.5 mm were connected to a preamplifier of 100 MΩ impedance. The data acquisition program used was (AcqKnowledge 3.9.1).

The active electrodes were placed at L1 and L5 bilaterally. The reference electrode was placed on the radial styloid process. The electrode placement followed the recommendations of *SENIAM* (Surface-EMG for the Non Invasive Assessment of Muscle). The volunteers were seated in an extension chair with a load cell attached at one end to a vest and at the other fixed onto the wall, with the hip fixed by a belt in 60° of flexion. To determine the MVIC the subjects performed three trials of maximal strength of trunk extension for five seconds each with a five minute rest period between the trials. The highest value was used as the reference.

The order of the loads (30, 50 and 75% of MVIC) was randomized. The volunteers supported the trunk extension until exhaustion and a monitor was positioned in front of the participants in order to control the solicited load. As the test duration varied between the subjects, it was necessary to normalize the signal by the time in seconds. The values of RMS (root mean square) and MF (median frequency) were calculated in windows of 10% of the final test time and for the MF the fast Fourier transform algorithm was used. The MF and RMS were normalized by the maximum values for each of the variables during the test and expressed as a percentage. The EMG signals were processed and filtered by subroutines in Matlab (version 7, The Mathworks Inc., Natick, MA).

The regression of the values of RMS in function of time to each load resulted in a respective slope. The EMG_{FT} of each muscle was defined through a new correlation between the loads and the slopes, thus, the EMG_{FT} is the point at which

the regression line from this last correlation intercepts the y-axis [5]. Also, the coefficient of determination had to be greater than 0.85 to be considered as the EMGFT [6].

RESULTS AND DISCUSSION

The mean of the Quebec Back Pain Questionnaire was 32 (SD=18.5) while the VAS was 2.4 cm (SD=1.5) before the assessment and 4.6 cm (SD=3.5) at the end. Figure 1 illustrates one example of a regression line found and the EMG_{FT} values are presented in table 1.

Determining the EMG_{FT} is an important tool used to analyze the performance of human movement [4]. However, the results of this study failed to determine the fatigue threshold. It is important to note that when a load is imposed to a muscle over a long period of time, spatial changes could occur and other portions of the same muscle become active [7]. The back muscles act synergistically during trunk extension, when a movement is constantly maintained, a co-contraction between the erector spinae muscles arises and a load distribution occurs between the muscles which generates a variation of activity, therefore there is a limitation on the capacity of the electrode to capture the real activity produced to maintain the established load. Thus, during sustained contractions, the muscles are continuously activated resulting in alternate periods of activity and passivity to support the produced force [8].

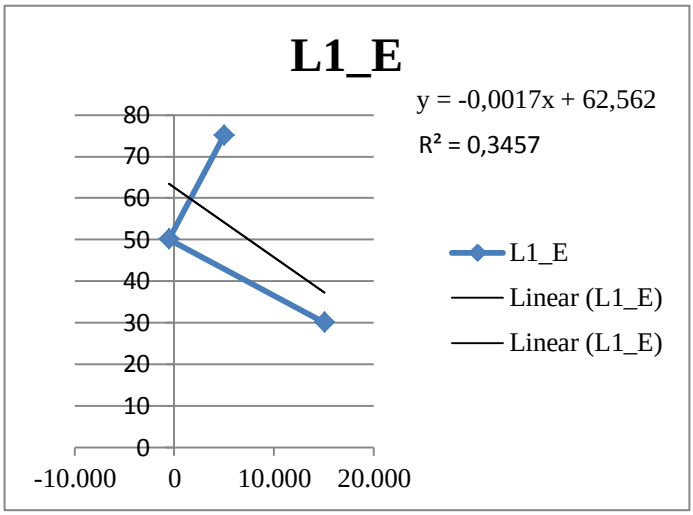

Figure 1: Example EMG_{FT} of a participant

Another limiting factor for the determination of EMG_{FT} is that subjects with low back pain seem to avoid excessive movement, as a protection factor to pain, which decreases the power generation, and is therefore unable to activate the muscles sufficiently to produce fatigue [9].

Sung et al., investigated the endurance of patients with and without low back pain through a non-linear analysis of EMG time series. The authors found that the entropic analysis of the time series between the healthy individuals and the subjects with low back pain showed significant differences in how fast the entropy saturated. The entropy associated with the subjects with low back pain saturated after very short-times, about two orders of magnitude shorter than for the healthy subjects [2]. It is worth mentioning that entropy is used to distinguish non-periodic random phenomena, including physiological time series, and indicates the rate of information production as it relates to dynamic systems [2].

However, the non-determination of EMG_{FT} could be related to the mathematical model used which depends on linear adaptations among the decrease of electromyography amplitude and the time during submaximal exercise [10]. The findings of this study suggest that non-linear models may be able to predict the $EMG_{FT,}$

CONCLUSIONS

It was not possible to determine the $EMG_{FT.}$

ACKNOWLEDGEMENTS

The authors wish to thank the financial support of the MCT/CNPq #014/2010, PPSUS/FA #CP 08/2009 and FA #25/2012.

REFERENCES

1. Wasiak R, et al.,*J Eval Clin Pract*.**14**:961-8, 2008.
2. Sung PS, et al., *Med Sci Monit*. **11**:CS1-5, 2005.
3. Bradl I, et al.,*Pathophysiology*. **12**:275-80, 2005.
4. Azevedo FM[tese], São Paulo:Universidade de São Paulo, 2007.
5. Bouillard K, et al.,*J Electromyogr Kinesiol*. **21:**229-35, 2011.
6. Hug F, et al., *Eur J Appl Physiol*.**107**:193-201, 2009.
7. Farina D, et al.,*J Electromyogr Kinesiol*.**18**:16-25, 2008.
8. Kouzaki M, et al.,*J Appl Physiol*. **93**:675-84, 2002.
9. Elfving B, et al.,*Clin Biomech*.**18**:619-30, 2003.
10. deVries HA, et al.,*Ergonomics*.**25**:783-91, 1982.

Table 1: Electromyography fatigue threshold.

	L1 D Md (quartiles)	**L1 E** Md(quartiles)	**L5 D** Md (quartiles)	**L5 E** Md (quartiles)
$FT_{EMG-RMS}$ (% MVIC)	51.6 (44.9 – 80.7)	55.8 (45.9 – 99.6)	44.5 (29.6 – 54.5)	36.6 (21.6 – 64.8)
FT_{EMG-FM} (% MVIC)	49.3(36.4 – 58.3)	59.9 (47.7 – 76.6)	43.9 (41.2 – 53.2)	48.3 (26.7 – 62.9)