ELECTROMYOGRAPHIC STUDY OF MUSCLE FATIGUE ON PATIENTS WITH CHRONIC LOW BACK PAIN

K.S.C. Kwong, F.T.F. Lam, C.W.Y. Hui-Chan
Department of Rehabilitation Sciences, The Hong Kong Polytechnic University, Hung Hom, Hong Kong

Introduction
Endurance of the back muscles is considered as an important contributing factor in the development of low back pain. Currently, researchers are looking at reliable methods for measuring the back muscle’s fatigue rate by surface electromyogram (EMG). Many of these studies are still at the experimental stage and the feasibility of using EMG as a clinical tool for such purpose remains uncertain. This study attempts to monitor and quantity muscular endurance of the back muscles through the measurement of surface EMG. The overall objectives of this study are: to measure the rate of fatigue of the back muscles on patients with chronic low back pain (CLBP) by surface EMG; to monitor endurance of back muscles in terms of EMG parameters; to compare these parameters between normal subjects and patients with CLBP; and to investigate the relationship between the median frequency parameters and physical characteristics of the subjects.

Methods
Twenty male patients with CLBP, aged between 20 and 40, were recruited in this study. They had persistent complaint of low back pain for at least 6 months, with an average duration of 2.15 (S.D. = 1.57) years. Twenty normal male subjects, matched in age, weight and height with the patients were also recruited for the study. The mean age of the patients and normal subjects were respectively 33.15 (S.D. = 6.06) and 32.65 (S.D. = 5.41) years. The test subject was positioned in prone with the lower part of the body held horizontally by straps around the ankles, knees and the pelvis. The upper part of the body was initially supported by an electric couch which was to be lowered down during the test. Both hands of the subject were placed at the back of the head. The skin where the electrodes were placed was shaved, adequately abraded with skin rub and cleaned with alcohol. The alignment of the electrodes was parallel to the muscle fibres of the iliocostalis lumbarum and the multifidus over the right side of the body. The inter-electrode distance was 25 mm and the active electrodes were placed at the level of L2-3 and L4-5 interspinous space for iliocostalis lumbarum and multifidus respectively. The ground electrodes were placed at the spinous processes of T10 and T12. Conductive gel (Elefix gel, Nihon Kohden) was used. During the test, the subject was instructed to keep his posture in prone, with the upper trunk maintained in an unsupported horizontal position (Sorenson’s test position) for 30 seconds while EMG were picked up from the two muscles. An inclinometer was used for monitoring the stability of the upper trunk during the tests, so that the trunk was kept to within 20 degrees with the horizontal. Two trials of 10 s each was given. An initial 30-second test was performed and EMG was recorded while the subject maintained in the testing position. Another 30-second measurement was repeated after the subject was given a rest of 1 minute. The EMG was picked up by two sets of silver-silver chloride disc electrodes of an effective diameter of
The EMG signals were captured and amplified (gain = 1000) through a dual channel biophysical amplifier (AVB021, Nihon Kohden), with CMRR of 80 dB. The signal was then acquired and digitized by a PC-based data acquisition board (Data Translation DT-2812-G-8DI) with 12-bit A/D conversion at 2500 Hz, operated on a general purpose data acquisition and signal processing software (Global Lab, Data Translation). The cut-off frequencies of the band-pass filter were set at 5 and 1000 Hz. A total of 10 one-second time-frames of EMG signal were extracted from each EMG record. This corresponded to the time period of 2-3s, 5-6s, 8-9s, 11-12s, 14-15s, 17-18s, 20-21s, 23-24s, 26-27s and 29-30s. For the time domain analysis, RMS voltage was measured. Each of these 10 time-frames were Fourier transformed to obtain a power spectrum, with Hanning window function used. A summation of each of the power spectrum was performed to obtain the total power. The median frequency (MF) was found by identifying the frequency which divided the total power spectrum into two equal halves. The MP slope was found by linear regression of the MF versus time plot. The y-intercept was taken as the initial MF. The pain level for the patient group was measured by a visual analogue scale (VAS). The MF values were normalized with respect to the initial MF. Comparison has been made between the fatigue rate of the normal subjects and the patients with CLBP. The EMG parameters chosen included the root-mean-square (RMS) slope, initial root-mean-square voltage, median frequency slope and initial median frequency.

Results & Discussion
A consistent change in RMS voltage was observed in both iliocostalis lumborum and multifidus. The RMS voltage gradually increased with time. This was also consistent with that measured after the rest. Therefore, positive values were found for the actual and normalized RMS slopes. The muscle activity of iliocostalis lumborum was always found to be higher than that of the multifidus. This study found a slope of 0.68 %/s (SD = 0.85) and 0.48 %/s (SD = 0.58) respectively for iliocostalis lumborum and multifidus. However, there was no significant difference because of the large S.D. A positive RMS slope was found on the normal subjects and patients. This could be explained by additional recruitment of motor units during sustained contraction of the back muscles. However, there was no significant difference found in the initial RMS voltage and the RMS slope between the normal subjects and the patients. It is therefore not possible to use RMS parameters alone to differentiate the endurance of the back muscles between these two groups of subjects. The MF was relatively less variable than the RMS slope. A negative MF slope was found on both normal subjects and the patients with CLBP. This could be explained by the accumulation of metabolites, leading to a decrease in the conduction velocity of motor units during fatiguing contraction. This was particularly noticeable on patients with CLBP. A steeper mean normalized MF slope (p < 0.05) for iliocostalis lumborum was found on the patients (-0.73 ± 0.26 %/s) when compared with the normal subjects (-0.51 ± 0.19 %/s). This suggested a poorer muscular endurance of this muscle on patients with CLBP. This observation could also imply a smaller percentage of type I muscle fibres in these patients. A possible explanation to such discrepancy is the difference in the characteristics of the back muscle function on patients with CLBP. The findings also suggested that the iliocostalis lumborum may take up a relatively greater load on patients with CLBP than the normal subjects, and therefore a
steeper slope was found for this muscle. There was no such difference identified between the multifidus of the normal subjects and the patients. The results did not show any correlation between the physical characteristics of the subjects and the MF. There was no significant difference in the initial MF and RMS parameters as the measurements recovered back to their normal values after 60 s. The subjects may therefore be regarded as sustaining a low load of fatiguing contraction during the Sorenson’s test. In summary, this study has confirmed the feasibility of using surface EMG parameters to document fatigue rate of back extensors. It has also established a protocol of MF measurement, which could be used for further development of a discriminative variable between normal subjects and patients with CLBP. Through this technique, the fatigue pattern of individual muscle group can be monitored objectively. Longitudinal monitoring of the fatigue rate and hence endurance of the back muscles could also be established in a clinical setting. It is expected that the use of surface EMG to quantify the endurance of back muscles could be further developed for applications in the rehabilitation of the back.

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