Flexion Relaxation Phenomenon of Back Muscles in Discriminating Between Healthy and Chronic Low Back Pain Women

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Introduction

Flexion relaxation phenomenon (FRP) is a phenomenon of silent or decreases electrical activity at the back muscles which occurs during flexion and extension of the trunk. In 1948, Allen [1] was the first researcher to describe that electrical activity in the erector spine suddenly decreases after a certain amount of trunk flexion. Later, it has been recognized as flexion relaxation phenomenon (FRP) in 1955 by Floyd and Silver [2]. FRP was found to occur at 40° to 70° of body flexion [3, 4] with the knees straight [5].

Previous studies [3, 4, 6] showed that FRP occurs in healthy subjects without low back pain (LBP). However, in LBP patients FRP is found frequently absent. FRP is then becomes a recognized indicator for low back dysfunction [2-4, 6-8]. Conversely, several studies demonstrated that back pain patients may also achieve FRP as healthy subjects. Study by Triano and Schulz [9] showed more than 50% of their patients did not achieve this phenomenon. While, Sihvonen *et. al.* [10] demonstrated only 36 from 87 LBP patients (41% of all patients) did not achieve FRP.

Several physiologic mechanisms have been proposed to explain the etiology of the FRP in the back muscles [2, 7, 8, 11-14].

Several studies [4, 16] have come out with calculation ratio of muscle activity between full flexion and partial flexion to compare between LBP and healthy subjects. This ratio involved by dividing the maximum root mean square (RMS) EMG signal values during partial flexion by the RMS of EMG signal during full flexion. Study by Watson *et al* showed that the flexion relaxation ratio (FRR) of the

LBP patients is lower than the healthy control subjects, it was demonstrated a highly significance differences between groups [4]. Geisser *et al* [17] preferred to use a similar method as Shirado *et al* [18] to calculate FRR. The FRR value was computed by employing normalization of the EMG values. Normalization of EMG was done by dividing the maximum EMG during flexion and average EMG in full flexion by the average EMG during standing. Then, the FRR value was acquired by dividing the normalized maximum EMG by the normalized average EMG in full flexion [17].

The objective of this study is to investigate quantitatively the surface electromyography (sEMG) signals of the low back muscles (L4-L5) during forward flexion and extension in healthy and LBP participants.

Subjects and methods

Subjects

Three groups of voluntary females, aged between 20 to 50 years old were recruited in this study. Consent form was obtained from each participant. Group 1 consists of 5 healthy women (mean age 28 ± 8; BMI 20.0 ± 0.9) while Group 2 consists of 5 LBP women with FRP (mean age 29±8; BMI 22.6± 3.1) and Group 3 consists of 5 LBP women without FRP (mean age 37±11; BMI 25.9± 8.0). LBP patients were defined as one who had not suffered LBP due to non-musculoskeletal disorder however; they experience an episode of LBP for at least 12 weeks. Pregnant women were excluded in this study.

Apparatus

Ag-AgCl surface electrodes (3cm diameter) were used to collect the electromyography (EMG) muscle activity of the sampled muscles. The EMG activity was recorded by using 8-channel Noraxon Telemyo2400T Gen 2 Telemetric Real – time which connected to a notebook. The EMG bandwidth was 10-500Hz at sampling rate 1500Hz without notch filter at 50Hz. The information was observed constantly on a monitor and stored digitally in raw form for further analysis using MATLAB 7.0 software at sampling rate of 1500Hz.

Experimental procedure

The participants were briefed on the study protocol which involved two types of forward flexion and extension with knee straight; maximum forward flexion (bowing as far as possible) (Figure 1) and 90^o forward flexion with hands on the knees (Figure 2) and return to the upright position.

The skin, area the fourth lumbar (L4) and fifth lumbar (L5) were cleaned thoroughly with an alcohol abrade. The spinal process of the L4 vertebra was identified and the Ag-AgCl surface electrodes were attached bilaterally about 2 cm laterals from spinous processes at L4 and L5 as shown in the Figure 3. The surface electrodes were attached to the participants' skin when the participants were in midflexion position to avoid loosens electrode during the bending cycle as suggested by Sihvonen [3]. The sEMG and motion signals were recorded during flexion and extension with knees straight and the feet about 15 cm apart. They were then required to practice the movements (*i.e.* maximum forward flexion and 90^o forward flexion) prior to testing to ensure that they could perform those movements. During EMG recordings, each movement was repeated three times to obtain the average signals. Basically the forward flexion and extension was divided into four phases; phase 1 standing (10 seconds), phase 2 forward flexion (2 s), phase 3 full flexion (5 s), and phase 4 extension (3 s). The whole cycle of the forward flexion and extension took approximately 20 seconds.

EMG analysis

The EMG signals were filtered using 4^{th} order high-pass Butterworth filter at 30Hz cutoff frequency to filter noises of movement (<20Hz) and electrocardiogram (ECG) (<30Hz).

High-pass filter at 30Hz cutoff frequency was found the best cutoff frequency to be used to filter ECG artifact in EMG signals [19-20].

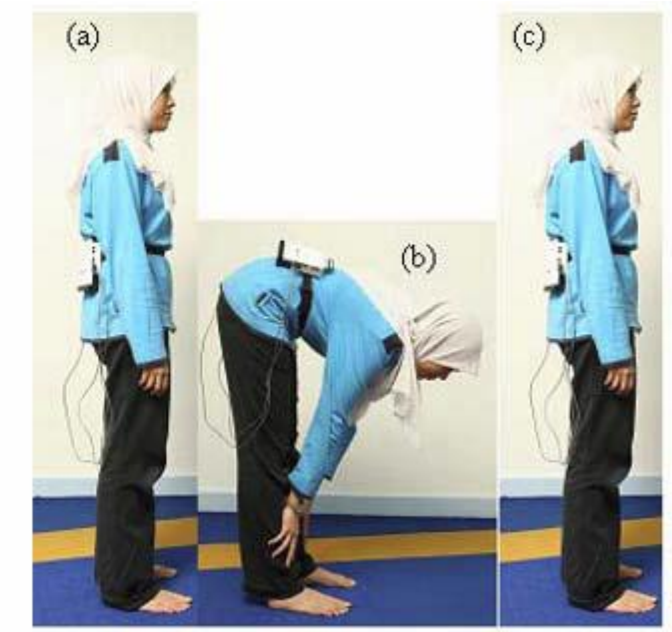

Fig. 1 The whole cycle of maximum forward

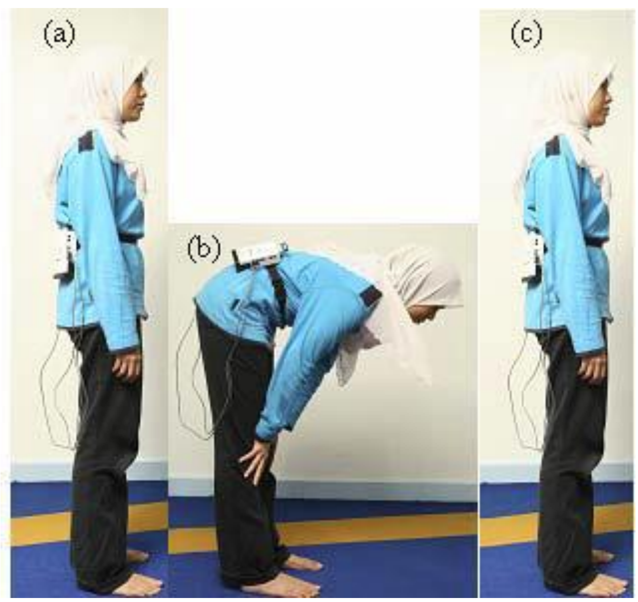

Fig. 2 The whole cycle of 90 degree forward flexion (b) and extension (c).

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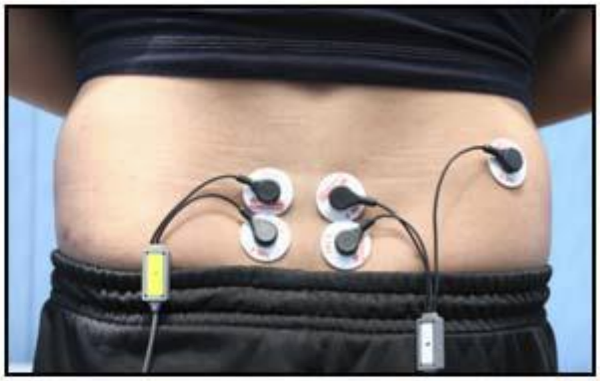

Fig. 3 Electrodes placement at L4-L5.

Next, RMS (at 50ms time period) of raw EMG signals was obtained. The EMG RMS signals from each participant were segmented into four phases as mentioned in the experimental procedure. Since this is the preliminary study, it focused and analyzed the EMG signal on the right side of the back muscles (L4-L5).