Low back muscle EMG pattern of non-specific low back pain individuals during normal gait

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ABSTRACT

Non-specific low back pain (LBP) symptom has been one of the most common work-related musculoskeletal problems, but reliable assessment in clinical settings often faces difficulties due to the lack of clear tissue damage or injury pathways. In this study, a new method of identifying the existence of non-specific LBP using simple evaluation of myoelectric muscle activities (EMG) has been tested to develop a reliable diagnosis method. Twenty participants who had non-specific LBP and nineteen healthy participants were recruited, and participated in a laboratory experiment. Surface EMG signals were recorded from the L2, L4 lumbar elector spinae muscles and external oblique, and rectus abdominis during approximately 2 min walking on a treadmill at a normal speed. Normalized amplitude of EMG signals were compared between the two groups. In results, it was found that the standard deviation and the maximum value of the normalized EMG of the L2 level muscles were significantly greater ($p<0.05$) for healthy group than for symptomatic participants. This result implies that the non-specific LBP patients could be identified by comparing the peak EMG of low back muscles with that of healthy individuals or possibly by calculating the ratio between the mean and maximum EMG values within symptomatic individual.

Keywords: EMG, low back muscle, lumbar spine, non-specific low back pain

1. Introduction

Low back pain (LBP) has been one of major health concerns for all working populations. Among all work-related LBP cases, more than 80% have been classified as non-specific or idiopathic LBPs as their direct causes or injury pathways are unknown. Due to the lack of clear causal factors and non-severe pain symptoms, non-specific LBPs have often been diagnosed by self-evaluation and report (Krismer and van Tulder, 2007).

One of commonly used self-evaluation tools for LBP is the Oswestry low back pain questionnaire (Fairbank, Pynsent, 2000; Davidson, Keating, 2001). The Oswestry questionnaire consists of 10 sections of questions that evaluate the level of disability. According to responses to the questions, each person is scored between 0 and 100. A high Oswestry score indicates more severe disability due to LBP (Table 1).

Table 1. Oswestry Disability Index.

Score	Meaning
0 – 20%	Minimal disability
21 – 40%	Moderate disability
41 – 60%	Severe disability
61 – 80%	Crippling back pain
81 – 100%	Bed-bound or have an exaggeration of symptoms

Some medical examinations have also been used to diagnose the non-specific LBPs, including both radiographic and non-radiographic assessments. However, due to the lack of clear injury

mechanism and the mild symptoms, it is typically difficult to reliably identify the existence of LBPs by the medical imaging evaluation.

To more reliably determine the existence and the level of LBP, previous experimental research has evaluated abnormality in biomechanical or physiological responses of symptomatic individuals such as the recruitment pattern and fatigue development of low back muscles in restrained isometric contraction exertions or controlled posture conditions (Larivière, 2011; Dankaerts 2004; Arena, 1989).

While results of these studies have consistently shown differences in biomechanical responses between healthy and symptomatic individuals, experimental methods and procedures of these studies cannot be easily repeated in non-laboratory settings such as clinics.

Reliable and more objective assessment of LBP in non-laboratory setting would help clinicians as well as researchers diagnose the LBP more easily and administer proper treatment or rehabilitation programs. Existing methods such as the Oswestry questionnaire or laboratory testing are either less repeatable or difficult to administer in non-laboratory environments. Therefore, the main objective of this study was to explore the possibility of the development of reliable and easy-to-perform assessment method for non-specific LBP, especially in normal walking trials.

2. Method

Myoelectric activity of the low back and abdominal muscles were quantified from healthy individuals and symptomatic individuals while walking at a normal speed. Their activation patterns between the two groups were compared to identify specific patterns that could distinguish the two groups.

Nineteen (9 females, 10 males) young (19 ~ 24 years old) healthy participants and twenty (10 females, 10 males) young (19 ~ 23 years old) symptomatic participants were recruited (Table 2). The symptomatic participants reported low back pain symptoms and scored the Oswestry questionnaire of greater 15. None of them, however, was receiving any medical treatment. Each participant provided informed consent on a protocol that was approved by the institutional review board.

Table 2. Characteristics of the healthy group and patient group with non-specific LBP (mean and SD).

Group	Age (years)	Height (cm)	Weight (kg)	Oswestry range (%)
Healthy group	20.9 (1.4)	169.6 (10.0)	61.9 (13.6)	.
Patient group	21.5 (2.1)	168.9 (9.9)	61.7 (8.5)	16~51

Surface electrodes (Delsys Bagnoli system, Delsys, U.S.A.) were used to record the myoelectric signal (EMG) bilaterally from the L2 and L4 level lumbar erector spinae muscles, external oblique muscles and rectus abdominal muscles.

With the 8 electrodes attached, each participant walked on a treadmill at 4 km/h for 2 minutes. No specific instruction was given except to look forward and walk normally with arms swinging freely. EMG data were recorded during the middle 60 seconds. Prior to the gait trial, the participant conducted an isometric back extension on a roman chair and a plank exercise for 20 seconds to register reference EMG amplitudes for low back and abdominal muscles, respectively.

Raw EMG signals of the gait trial were demeaned, and band pass filtered between 30 and 500 Hz. Then, linear envelop EMG was computed for each channel by the 2nd-order butterworth filter with a cut off frequency of 6 Hz. The processed EMG of the lumbar erector spinae muscles were normalized by the reference EMG of isometric back extension, and the EMG of the abdominal muscles were normalized by the reference EMG of the plank exercise.

From the normalized EMG data of the 60 seconds walking, data of 10 left leg strides and 10 right leg strides were extracted. The onset and end of each

stride were determined by the cyclic pattern of EMG of the L2 level lumbar erector spinae muscle (Anders, 2007).

The differences in the normalized EMG amplitudes between two groups were statistically compared by two-way nested ANOVA with the 'participant' nested within 'group' variable. Significance criterion of $p<0.05$ was used for all analyses.

3. Results and Discussion

No significant difference between groups was found from the minimum, mean and the 10^{th} %-tile values of the normalized EMG of the lumbar erector spinae muscles. However, the standard deviation (SD) and the maximum value of the normalized EMG of the L2 level muscles were significantly greater for healthy group than for symptomatic participants (Fig. 1 and Fig. 2).

The lower peak activity levels and resultant less variation of the lumbar erector spinae muscles of the symptomatic participants might be attributable to their atrophied activation patterns to protect their injured low back musculature. This result suggests that the existence of non-specific LBP symptoms could be detected by quantifying the peak EMG amplitudes of the low back extensor muscles and comparing the values with that of healthy individuals or possibly by calculating the ratio between the mean and max low back EMG values within each symptomatic individual.

Differences in muscle activation patterns between healthy and non-specific LBP patients have been reported frequently in previous research. Most of them collected data during controlled posture or movement conditions that could not be easily repeated in non-laboratory settings. Findings of the current study suggest that the muscle activation patterns of the two groups could be distinguished in less controlled movement such as a normal walking.

4. Conclusion

In this study, it was found that noticeable difference in the low back muscle EMG pattern between non-specific low back pain individuals and healthy individuals could be detected during normal walking. It may help researchers develop a more systematic data collection and analysis protocols and relevant hardware to be used as an easy screening tool for non-specific LBP in clinical settings.

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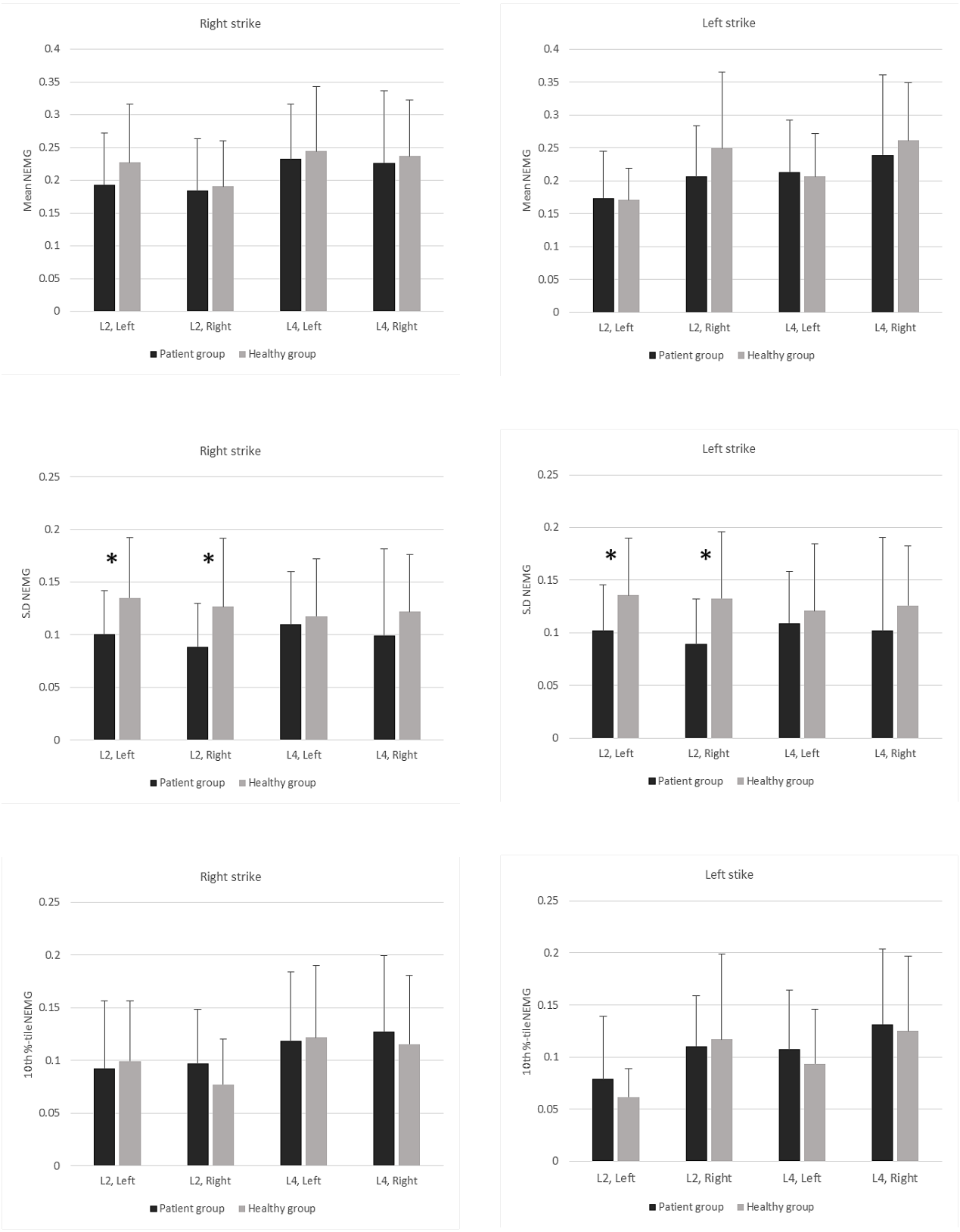

Figure 1. Mean, standard deviation (SD), and 10th %-tile of NEMG of L2 and L4 level lumbar erector spinae muscles.

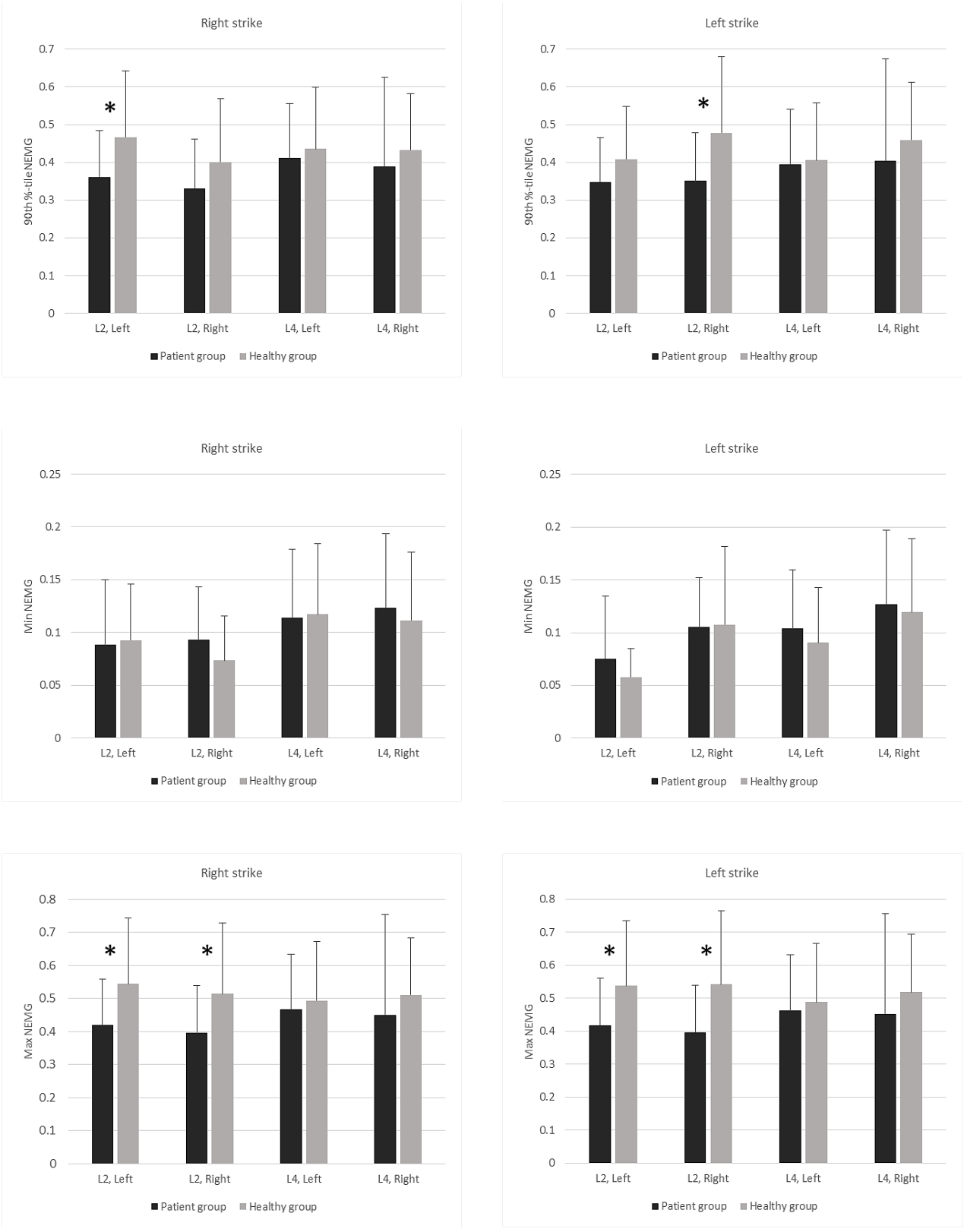

Figure 2. 90th %-tile, minimum, and maximum value of NEMG of L2 and L4 level lumbar erector spinae muscles.