

Relationship between subjective pain scale and muscle recruitment patterns of low back

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ABSTRACT

Objective: The main objective of this study was to investigate the relationship between self-reported back pain severity and muscle recruitment patterns while conducting common physical exercises. **Background:** Non-specific low back pain has been one of major concerns in various occupational environments. Reliable and quantitative assessment of the severity of non-specific low back pain is important in injury prevention as well as rehabilitation of injured individuals. While self-reported questionnaires such as the Oswestry Low Back Disability questionnaire have been frequently used to assess the severity of non-specific low back pain, no quantitative and objective assessment tool or system has yet been developed. **Method:** Twenty seven participants who had low back pain symptoms were grouped into three groups by their Oswestry disability score (less than 22; 23-30; greater than 30), and participated in a laboratory experiment. Myoelectric signals (EMG) of the lumbar erector spinae muscles and abdominal muscles were collected from each participant during common physical exercises, including walking, plank, bird-dog, and isometric back extension. Mean amplitude of each muscle, bilateral difference between left and right side muscles, and co-contraction ratio between abdominal and low back muscles were compared between the three Oswestry score groups. **Results:** Significant differences between score groups were observed only from the bird-dog exercise. Greater bilateral difference of the L2 lumbar erector spinae muscles and smaller bilateral difference of the rectus abdominal muscles were observed from groups with higher Oswestry scores. **Conclusion:** Severity of non-specific low back pain could be quantitatively assessed from the evaluation of muscle recruitment patterns in non-symmetric exercises such as bird-dog. **Application:** Results of this pioneering study could be used to develop reliable and easy-to-use low back health monitoring systems.

Keywords: EMG, low back, lumbar spine, OSWESTRY

1. Introduction

Low back pain (LBP) has been one of the most frequently occurred pain symptoms among working population. Due to the lack of clear mechanism of injury or causal factors, most LBP cases have been classified as non-specific LBPs and diagnosed by self-reports of pain severity and characteristics (Walker 2000; Balague et al., 2012).

One of common subjective assessment tool for LBP is the Oswestry low back disability questionnaire (Fairbank, Pynsent, 2000; Davidson, Keating, 2001).

The Oswestry questionnaire consists of 10 sections that collect information regarding how the responder's low back pain is influencing his/her everyday life. Higher score within the range of 0 to 100% indicates more severe level of LBP (Table 1).

While the Oswestry index and other subjective assessment tools have been frequently used to determine the level of pain symptoms of non-specific LBPs, it has not been sufficiently evaluated how the scores of the subjective assessment tools are related to physiologic or biomechanical responses. Quantitative relationships between subjectively determined pain levels and objectively measured physiologic responses, if well

established, could be valuable information for the understanding of the injury mechanism of non-specific low back pain.

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

In previous research, various evaluation methods of myoelectric signals (EMG) of low back and neighboring muscles have been frequently used to determine abnormal status of the low back musculature such as the timing of flexion-relaxation phenomenon of low back extensor muscles, occurrence and strength of muscle spasms, and changes in co-contraction ratio between agonist and antagonist muscles (Zhu and Shin, 2013; Granata and Orishimo, 2001). Although these indicators have shown good reliability and validity in determining the existence of abnormality of the low back musculature, it has not been well studied whether these EMG indicators can sensitively assess the level of abnormality of the low back. To evaluate the sensitivity of the EMG indicators in differentiating the severity of neuromuscular abnormality of low back musculature, it is important to compare muscle recruitment patterns and signal strengths between individuals of different low back health status.

The main objective of this experimental study was to explore the possibility of using the surface EMG for the evaluation of low back health status by identifying specific EMG indicators and muscle recruitment patterns that could differentiate individuals of different level of non-specific LBP symptoms.

2. Method

Twenty seven (14 females, 13 males) young (19 ~ 23 years old) individual who had low back pain symptoms were recruited for a laboratory experiment. They were grouped into three groups by the Oswestry discomfort

scores (Table 2). Each participant provided a consent on a protocol approved by the institutional review board.

Table 2. Participant information.

Group	Oswestry score	Mean height, cm	Mean weight, kg
1 (n = 8)	10 ~ 22%	168.4	63.5
2 (n = 9)	23 ~ 30%	168.4	60.8
3 (n = 10)	31 ~ 51%	169.1	59.2

Each participant participated in an experiment on a single day and conducted several physical exercise activities while the myoelectric signals of the low back extensors and abdominal muscles were collected. The physical exercises included normal treadmill walking (4 ~ 6 km/h) for 1 minute, maintaining a plank posture for 20 seconds, maintaining an isometric back extension posture on a roman chair for 20 seconds, and maintaining bird-dog postures on a flat bed. The participant conducted these exercises in series with short rest breaks between consecutive exercises.

While conducting the above listed exercises, the EMG signals were collected by the surface electrodes (Delsys Bagnoli system, Delsys, U.S.A.) from the L2 and L4 level lumbar erector spinae muscles, external oblique muscles and rectus abdominal muscles bilaterally. Raw EMG signals were processed by typical smoothing algorithms to produce RMS (root mean square) EMG. RMS EMG of the middle 5 seconds during each exercise were averaged, and then divided by the mean RMS EMG of the plank (for abdominal muscles) or the isometric back extension (for lumbar erector spinae muscles) exercise to produce the normalized mean RMS EMG of each muscle.

The normalized mean EMG data were then compared between groups to understand the variation of EMG patterns between individuals of different pain symptom levels.

3. Results and Discussion

Mean normalized EMG of lumbar erector spinae muscles showed a decreasing trend as the Oswestry

score increased when conducting the bird-dog exercises (Fig. 1). Specifically, the activity of ipsilateral L2 lumbar erector spinae muscles decreased more noticeably than the contralateral side, resulting in greater asymmetry for Group 3 than for Group 1 (Table 3). Other than the lumbar erector spinae muscles in the bird-dog exercises, no noticeable differences were found between groups.

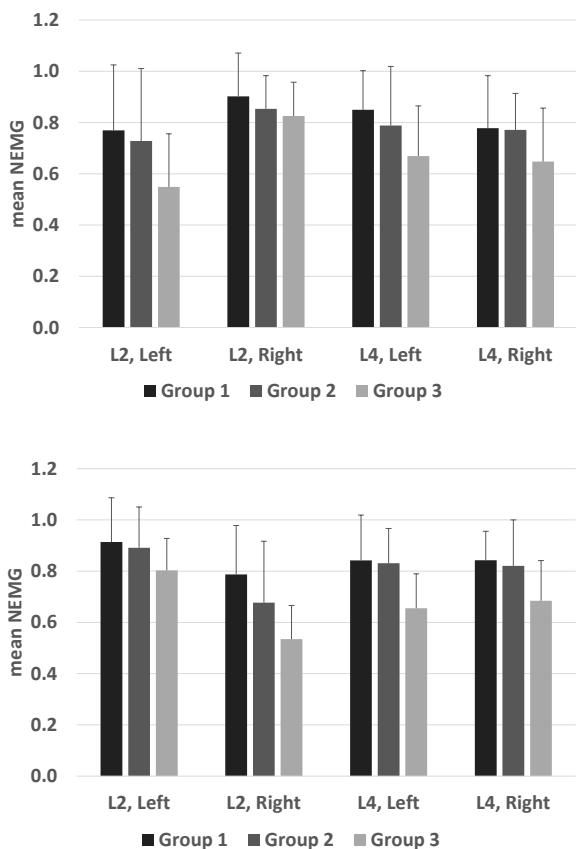


Figure 1. Mean NEMG of lumbar erector spinae muscles in left-leg raising bird-dog (top), and right-leg raising bird-dog (bottom) exercises.

Results of this pioneering study, while still need substantial refinements and investigation, suggest that the surface EMG of low back extensor muscles could be used to identify differences in the neuromuscular health status, which have often been diagnosed by self-evaluation of patients. Specifically, the larger asymmetry in the activity of L2 level lumbar erector spinae muscles from the Group 3 participants indicates that the evaluation

of bilateral difference in the muscle activity could serve as a sensitive indicator for the evaluation of pain levels or health status of the low back, with minimal influence of individual differences.

Table 3. Bilateral asymmetry ratio of lumbar erector spinae NEMG in bird-dog exercise.

	L2 left/right	L4 left/right
Left-leg raising		
Group 1	0.84	1.15
Group 2	0.86	1.03
Group 3	0.67	1.08
Right-leg raising		
Group 1	1.19	1.00
Group 2	1.48	1.04
Group 3	1.60	0.98

It should be noted that the findings of this study are preliminary results that need further evaluation and interpretation. Future research with more test conditions and EMG variables will expand and strengthen the findings of the current study.

4. Conclusion

In this pioneering study, it was found that the evaluation bilateral difference, or asymmetry of L2 level lumbar erector spinae muscles in bird-dog exercises could be used as a sensitive method to determine the level of pain symptoms of individuals who have non-specific low back pain. Results suggest the potential use of surface EMG for quick and easy assessment of neuromuscular health status of the low back.

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