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Muscle Inhibition During Cycling in a Patient with Chronic Low Back Pain: Effect of Brief Electrical Stimulation

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Abstract

Background and purpose: This case study reports patterns of muscle inhibition and techniques for therapeutic intervention in a well-trained cyclist with chronic low back pain (CLBP) following a discectomy at L5-S1. It has been shown that repeated or prolonged flexion can lead to inhibition of the spine stabilizing muscles. Competitive cyclists exert high effort in a flexed posture for prolonged periods. Segmental muscle inhibition could lead to LBP and segmental instability in this population. The purpose of our case study was 1) to determine if a competitive cyclist with CLBP would demonstrate muscle inhibition at the symptomatic level and 2) to determine if a therapeutic intervention (electrical muscle stimulation) applied to the symptomatic level for a short period, could affect function.

Methods: One subject, a 42-year-old male, rode a stationary bike trainer at various speeds and gear configurations for specified time periods. Surface EMG was recorded at L3-L4, L4-L5 and the L5-S1 segmental levels for 10 seconds during 7 trials. Electrical stimulation was applied in prone for a period of 15 minutes, using square waves with 120 ms pulse width at 35 Hz. Two cycling trials were conducted before therapeutic intervention and five were recorded after intervention.

Analysis/results: Analysis was performed using normalized RMS surface EMG. Therapeutic intervention, consisting of 15 minutes of electrical muscle stimulation, improved muscle recruitment at the symptomatic level to values better than adjacent segments. Further, this stimulation effect persisted up to 15 minutes while cycling continued. Discussion: Even though competitive cyclists are subjected to a flexed spine position for long periods of time, electrical stimulation may lead to improvement in lumbar muscle recruitment, and presumably to improved spinal stability and motor control. Further studies are needed to determine the optimal timing of stimulation and how long the effect can last under competitive conditions.

Conclusion: Cyclists with CLBP are at risk for inhibition of the lumbar stabilizing muscles. With electrical stimulation and proper rehabilitation, this inhibition may be reduced. Clinical Implications; This study exposes one of the neuromusculoskeletal risks competitive cyclists with CLBP can face, and proposes a relatively novel intervention. Further research is required to validate these results.

Keywords: CLBP; Cycling; Inhibition; Electrical stimulation

Introduction

Cyclists engage in their sport by maintaining a flexed posture. While in the saddle, their pelvis is positioned so that the pubic bones are supported by the saddle. Professional cyclists are required to keep their legs moving in a piston type motion while riding, resulting in variable stress to their spine. It has also been speculated that variables such as seat position and pedal location can change spinal stress during pedalling [1]. Inhibition of the multifidus muscle has been shown to occur during static postures, especially into trunk flexion [2]. Prolonged flexion for up to 20 minutes was enough to shut down the EMG activity of the lumbar multifidus for up to 7 hours [3].

Motor control is a critical issue for all types of athletes, who require maximal muscular output over sustained time periods. This is especially true for competitive cyclists who must deal with a range of issues, including variable terrain, pain, and fatigue, all of which can influence muscle function [4]. It is widely accepted that spinal stability is a crucial variable in lower extremity force output [5]. Muscles such as multifidus and transversus abdominus have been implicated in dynamic spine stabilization [6,7]. Although chronic low back pain has been associated with changes in multiple systems [8], it has been demonstrated that specific training can alter muscle recruitment patterns [9]. However, the role of electrical stimulation is less clear. Our dual hypotheses were: 1) even a highly-trained athlete would exhibit inhibition of lumbar musculature at the site of surgical intervention (L5-S1) during stationary cycling; and 2) the lumbar muscle recruitment at L5-S1 could be improved by an isolated bout of electrical stimulation and would persist for a functional period post-stimulation.

Methods and Materials

One male, 42 years old, 86 kg, 176.5 cm tall, participated in this study. He had CLBP for many years and 8 years previously underwent L5-S1 lumbar laminectomy for an extruded disc on the left side. He had some residual numbness in his left leg for some time after the surgery and continued to exercise to improve the trunk and hip musculature. The subject rode a Giant (Giant Bicycles 3587 Old Conejo Rd, Newbury Park, CA 91320) carbon fiber composite road racing bike, OCR2, for the duration of this study (Figure 1). The back tire was placed on the trainer with the front tired secured in a harness. Height from the top of the down tube to the seat bottom was 5.9 cm. The fore/aft measurement was 2.5 mm. These measurements resulted in a comfortable riding position without apparent end range joint restrictions. Following preparation of the area by shaving and alcohol wipe, pairs of bipolar Ag–AgCl surface electrodes (3 cm inter-electrode distance, 1 cm active diameter, (Blue

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Sensor, Medicotest, Denmark) were placed on the muscle bulk of each muscle paraspinally on the left and right side at each level. A reference electrode was placed in the midline at the level of T12 (Figure 2). An EMG system with bandpass of 10–1000 Hz, CCRR 90 dB (TELEMYO 2400, Noraxon, Scottsdale, Arizona) was used to record surface EMG activity at 1000 Hz. EMG data were processed by calculating the root-mean-square (RMS) power of the signal. The data were then smoothed by averaging over 50 data points. The average for each channel was calculated over a 10 second envelope. Finally, averages for each channel for each trial were normalized to the averaged RMS resting EMG for each channel (Figure 3).

Figure 1: Giant bicycle set-up on trainer.

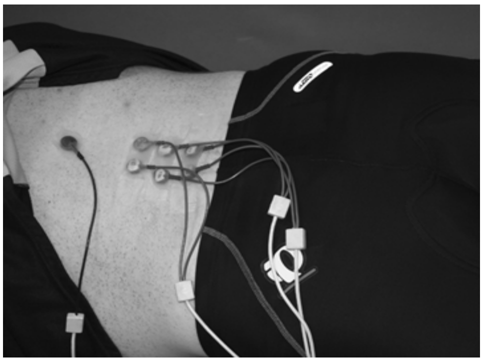

Figure 2: Electrode placement at L3-L4, L4-L5 and L5-S1.

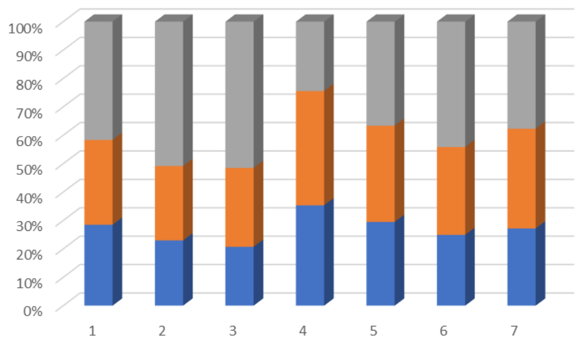

Figure 3: Smoothed, normalized RMS EMG by trial.

Before the trials, 10 seconds of resting EMG were recorded, to evaluate ambient noise and electrode placements. Prior to testing, the subject rode for 5 minutes at a comfortable speed to warm up. During all subsequent cycling trials, 10 seconds of EMG were recorded during mid-trial when the subject had reached a steady state. The first recorded trial was a ride at a constant speed of 23 MPH for 2 minutes. This was followed by a rest period of 5 minutes, then a sprint at 37.0 MPH for 30 seconds. After these trials, two miniature stimulating electrodes (3 inches in diameter) were applied to the lumbar spine at the L5-S1 segmental level on the left side. The stimulation was applied for a period of 15 minutes at 30 HZ and a pulse width was set at 110 with the subject in prone [10]. Subsequent trials varied speed and distance (Table 1). Immediately after the stimulation ended, the subject began to ride again at a speed of 23 MPH for 15 minutes. This was followed by a sprint at 41 mph for 30 seconds. This was followed by a sprint at 37 MPH for 2 minutes. A 23-mile followed this hour ride for 15 minutes. After these trials, the stimulating electrodes were again applied on the left side of the L5-S1 segmental level. Stimulation was applied for 15 minutes. After the stimulation, the subject rode at 23.0 MPH for 2 minutes.

Results

Our first hypothesis was not supported. Comparing the output of the three levels, the ratio of L5 EMG to L3+L4 EMG was always above 33%, with the exception of trial 4, the only 41 mph sprint. In that trial, the ratio of L5 EMG to combined L3 and L4 EMG was 32% (Figure 3). There did appear to be support for our second hypothesis, that electrical stimulation could improve lumbar muscle function. The highest ratio of L5 to L3+L4 EMG occurred in the trial immediately after the first stimulation, a steady 23 mph trial. The ratio was 1.06, which, compared to the first 23 mph trial ratios of 0.43, suggests that L5 EMG output was enhanced after the stimulation. However, the second bout of stimulation, occurring just prior to the last trial did not have a similar effect. The L5 ratio in trial 6, prior to the stimulation, was 0.789. After stimulation, in the last trial, the ratio fell to 0.605. Overall, the highest EMG from all levels was elicited in trial 5, the 37-mph sprint (L5 ratio 0.578), followed closely by trial 4, the 41-mph sprint (Table 1).

Discussion

While these data are preliminary, they do indicate a role for electrical stimulation in functional recruitment of lumbar muscles during cycling for patients with previous low back surgery. We hypothesize that the lack of response to stimulation near the end of the trials may have been due to fatigue. In a sprint cycling study, Bishop demonstrated an immediate and continuing decline in force output over a series of 10 sprint trials [11]. The lack of observable deficit in multifidus recruitment at the surgical site (L5-S1) may be due, in part, to the surface electrodes used in our study, since it has been shown that surface EMG does not accurately reflect the contribution of the lumbar multifidus [12]. The output of the impaired level (L5) only dipped below parity with the other lumbar levels during the 41-mph sprint. This may suggest that, using surface EMG, the muscular deficit is only apparent at the highest effort levels.

In general, research supports the use of electrical stimulation to recruit spinal stabilizing muscles at various segmental levels [13]. Our data reflect an immediate enhanced recruitment in the L5-S1 muscle fibers post-stimulation after two trials (15.5 minutes of cycling). However, the enhancement was short-lived, lasting only about 15 minutes. Further efficacy studies are needed to support the use of electrical stimulation to recruit the lumbar stabilizing muscles during recreational activities. Specifically, when the activity has a flexion moment associated with it (such as cycling) will the stimulation be

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7
Average Speed (mph)	23	37	23	41	37	23	23
Duration (minutes)	15	0.5	15	15	0.75	15	2
L5 EMG Ratio relative to L3+L4	0.43	1.03	1.06	0.32	0.58	0.79	0.6
		Δ				Δ	
		Stimulation applied				Stimulation applied	

Table 1: Trial by type and duration with EMG ratios.

able to counteract this and keep the lumbar stabilizers from shutting down? The preliminary answer appears to be yes, but during a long road race, such as a major tour, will the stimulation be able to avert or delay fatigue? This remains an open question.

Conclusion

This study suggests that using electrical stimulation for a brief period may enhance the recruitment of lumbar stabilizing muscles, even in a task with significant inhibiting components like the flexed posture of cycling. However, the muscle recruitment response we observed was time-limited and seems to have been diminished by fatigue over the seven trials. We hope that researchers will be excited by our preliminary results, and that future well-designed studies on this topic will help to elucidate some of the answers to the questions raised.

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