ACCRAC Award Winning Paper

Neuromechanical Responses After Biofeedback Training in Participants With Chronic Low Back Pain: An Experimental Cohort Study

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Abstract

Objective: The objective of this study was to evaluate changes in neuromechanical responses and clinical outcomes in chronic low back pain participants after 4 sessions of biofeedback training.

Methods: Twenty-one participants took part in an electromyography biofeedback 4-session training program aimed at reducing lumbar paraspinal muscle activity during full trunk flexion. The sessions consisted of ~46 trunk flexion-extension divided into 5 blocks. The effects of training blocks and sessions on lumbar flexion-relaxation ratio and lumbopelvic ranges of motion were assessed. Changes in disability (Oswestry Disability Index), pain intensity (numerical rating scale), and fear of movement (Tampa Scale for Kinesiophobia) were also evaluated.

Results: Analyses of variance revealed a significant block effect for which an increase in the flexion-relaxation ratio and the lumbar range of motion between block 1 and the other blocks for sessions 1 and 2 ($P < .0001$) was observed. However, no significant session or interaction effect was observed. Among clinical outcomes, only fear of movement significantly decreased between the baseline (mean [SD], 33.05 [7.18]) and the fourth session (29.80 [9.88]) ($P = .02$). There was no significant correlation between clinical outcomes and neuromechanical variables.

Conclusion: Biofeedback training led to decreases in lumbar paraspinal muscle activity in full trunk flexion and increases in lumbopelvic range of motion in participants with chronic nonspecific low back pain. Although the neuromechanical changes were mostly observed at the early stage of the program, the presence of a decrease in the fear of movement suggests that the participants' initially limited ROMs may have been modulated by fear avoidance behaviors. (J Manipulative Physiol Ther 2015;38:449-457)

Key Indexing Terms: *Biofeedback; Low Back Pain; Rehabilitation; Electromyography; Stress; Mechanical*

Biofeedback is the technique by which biological information, naturally imperceptible, is converted into meaningful cues and provided to patients in real time.[1,2] It is often used as a self-regulation procedure where patients learn to voluntarily gain control of physiological processes, and it provides the opportunity to improve various physiological functions such as motor control. It also prompts engagement in active rehabilitation and reduces the need for ongoing health care professionals' assistance, while facilitating return to well-being.[1-3] Parameters targeted by rehabilitative interventions to facilitate return to normal function can be divided into 2 main categories; physiological and biomechanical. The neuromuscular system is by far the most studied of the physiological systems, with several studies investigating the effect of electromyography (EMG) and real-time ultrasound imaging of various clinical situations ranging from accelerated recovery after knee surgery and maximized function after cardiovascular accident to reduction of muscles activation in chronic neck and

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Human subjects and animals: Comité d'éthique de la recherche avec les êtres humains de l'Université du Québec à Trois-Rivières.

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shoulder pain.[1] The proposed mechanisms that explain the effectiveness of prolonged biofeedback training lie in the activation of new or unused synapses leading to memory trace of motor commands.[4] Current evidence has identified a variety of medical and psychological disorders that can be effectively treated with biofeedback, alone or in combination with other behavioral therapies.[3] As such, biofeedback training is recommended and recognized as an effective part of rehabilitation regimens for chronic pain conditions such as headache and temporomandibular joint pain.[3] Its use allows patients with sensorimotor impairments to recover the ability to better evaluate the different physiological responses and thus possibly learn to control these responses.[4] In accordance with current theories, improvement of motor control through motor plasticity may be enhanced by high-quality biofeedback under pain-free circumstances.[5] The flexion-relaxation phenomenon (FRP), a well-known and studied trunk neuromuscular response, is a reliable discriminant between patients with and without low back pain (LBP) and allows for the identification of changes in muscle activity patterns.[6] During a trunk flexion-extension, healthy subjects (without LBP) exhibit a reduction in, or a silence of, the EMG signal of the lumbar erector spinae. Absence of the FRP, that is, the maintenance of the lumbar muscles' EMG signal, in patients with LBP may be attributable to different causes, and its restoration can be achieved with appropriate intervention.[5,7]

The purpose of the present study was to evaluate changes in neuromechanical responses and clinical outcomes after a 4-session biofeedback training program. The program targeted the capacity of participants with chronic LBP to decrease their lumbar paraspinal muscle activity during full trunk flexions and the relationships between changes in neuromechanical variables and clinical outcomes. The study was conducted not only to assess the possible changes in neuromechanical responses and clinical outcomes after biofeedback sessions but also to generate preliminary data for the design of a larger randomized control trial. Considering the results of previous studies, it was hypothesized that as the sessions progressed, participants would decrease their lumbar muscles activity and increase their lumbopelvic range of motion (ROM) and that these gains would be correlated to improved clinical outcomes.

Methods

Participants

Participants were recruited through advertisement in the local newspaper and were first screened by an experienced clinician to assess for the presence of exclusion criteria. Sample size was calculated using an estimated moderate effect size of 0.30, with a significance level of 0.05 and a desired power of 0.80. The effect size was chosen considering that biofeedback training has been previously shown to improve the decrease in lumbar paraspinal muscle activity during full trunk flexion when combined to a functional restoration program compared to a functional restoration program alone.[8] Sample size was computed to assess both intersession and intrasession changes. Considering the aforementioned requirements, a minimum of 17 participants were needed. Volunteers between 18 and 60 years of age with nonspecific chronic LBP were invited to participate in the study. *Chronic LBP* was defined as episodic or constant pain present for more than 12 weeks, located between the 12th rib and the inferior gluteal fold for which no specific source of pain could be identified. Exclusion criteria included LBP of specific origin,[9] spine surgery or trauma, scoliosis, neurologic disease, uncontrolled hypertension, pregnancy, incapacity to perform a trunk flexion, recent lumbar cortisone injection, and being under medications known to impair physical effort and pain perception. All participants provided their informed written consent in accordance to the Comité d'éthique de la recherche avec des êtres humains de l'Université du Québec à Trois-Rivières (CER-13-196-07.06), and the study was registered at ClinicalTrials.gov (NCT02239289).

Clinical Outcomes

Before baseline evaluation, participants were required to complete an initial questionnaire including, among other information, sex, age, height, weight, and employment status. The Oswestry Disability Index (ODI), a 101-point Numerical Rating Scale (NRS), and the Tampa Scale for Kinesiophobia (TSK) were used to respectively quantify lumbar disability, mean pain intensity in the past week and current pain intensity, and fear of movement. All these questionnaires have been reported to be reliable and responsive in the treatment of chronic LBP, and their French versions, which were used, have been validated.[10,11] Assessments of these outcomes were completed at baseline and after the fourth session, with the exception of the NRS which was completed at the beginning of each session.

Experimental Protocol

The four 180-minute sessions were conducted at the university's neuromechanics and motor control laboratory over the span of 4 to 6 weeks. Before experimentation, the difference between participants with chronic LBP and healthy individuals during a flexion-extension task (absence of the FRP in participants with LBP) was explained to the participants, and the task was demonstrated. Throughout the sessions, participants were reminded that the ultimate goal of the training program was to regain a healthy neuromuscular pattern without increasing the level of pain or disability.

Flexion-Extension Task

Participants were asked to perform a trunk flexion-extension, which was divided into 4 phases (Fig 1): (1)