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Original article

Altered postural responses persist following physical therapy of general versus specific trunk exercises in people with low back pain

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A B S T R A C T

Interventions that target trunk muscle impairments in people with LBP have been promoted; however, the treatment effects on muscle activation impairments during postural tasks remain unclear. Thus, our objective was to evaluate the effects trunk stabilization vs. general strength and conditioning exercises on the automatic postural response in persons with chronic low back pain (LBP).

Fifty-eight subjects with chronic, recurrent LBP ($n = 58$) (i.e., longer than six months) were recruited and randomly assigned to one of two, 10-week physical therapy programs: stabilization ($n = 29$) or strength and conditioning ($n = 29$). Pain and function were measured at 11 weeks and 6 months post-treatment initiation. To quantify postural following support surface perturbations, surface electrodes recorded electromyography (EMG) of trunk and leg muscles and force plates recorded forces under the feet, to calculate the center of pressure.

Both groups demonstrated significant improvements in pain and function out to 6 months. There were also changes in muscle activation patterns immediately post-treatment, but not at 6 months. However, changes in center of pressure (COP) responses were treatment specific. Following treatment, the stabilization group demonstrated later onset of COP displacement, while the onset of COP displacement in the strengthening group was significantly earlier following treatment.

Despite two different treatments, clinical improvements and muscle activation patterns were similar for both groups, indicating that the stabilization treatment protocol does not preferentially improve treatment outcomes or inter-muscle postural coordination patterns for persons with LBP.

Clinical Trial Registration Number: NCT01611792.

1. Introduction

Impaired automatic postural responses (APR) are associated with chronic low back pain (LBP) (Mok et al., 2004; Henry et al., 2006). APRs reflect the nervous system's ability to rapidly organize and execute multi-segmental, functionally-relevant muscle activation patterns in response to externally induced perturbations. Compared to APRs in healthy subjects, persons with LBP demonstrate delayed and reduced EMG activity (Radebold et al., 2000; Stokes et al., 2006), delayed centers of pressure (COP), and reduced COP excursion (e.g., margin of stability) (Henry et al., 2006) in sagittal plane perturbations (Newcomer et al., 2002), suggesting that persons with LBP rely less on a hip strategy (Mok et al., 2004; Henry et al., 2006). The hip strategy combines trunk and hip motion to generate shear forces resulting from torques at the hip joint rather than ankle joint in order to maintain equilibrium (Henry et al., 2006). Subjects with LBP may be (Radebold et al., 2000) reluctant to use a hip strategy in response to sagittal perturbations due to anticipated pain or increased trunk muscle activity associated with these large trunk movements. Thus, impaired APRs may contribute to LBP recurrence and thus should be addressed in treatment.

In healthy persons lateral surface perturbations are characterized by initial activation of the tensor fascia latae muscle (a hip abductor which aids in stabilizing the pelvis) of the loaded leg (Henry et al., 1998). In contrast, persons with LBP have demonstrated delays in COP onset during lateral perturbations (Henry et al., 2006), which are also indicative of an impaired hip strategy

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and trunk stiffening. None of these studies specifically examined the treatment response of the APRs to lateral perturbations, which typically rely on a hip strategy (Henry et al., 1998).

Whether these impaired APRs are the cause or consequence of LBP is unknown, presenting a treatment challenge for clinicians. Physical therapists (PT) design treatment programs to ameliorate impaired APRs for people with LBP (e.g., O'Sullivan and Allison, 1997; Richardson et al., 1999), based on the assumption that there is a causal relationship between motor control impairments and LBP (Hodges et al., 1999; Tsao and Hodges, 2008). One program, the trunk stabilization exercise (STB) program, focuses on ameliorating motor control impairments by improving control and strength of deep trunk muscles (Richardson et al., 2004). It is unknown whether STB influences the motor control responses to perturbations and/or reduces LBP compared to general strength/conditioning treatment (STC) programs or which treatment has the greatest potential to improve pain/function and ameliorate motor control impairments in persons with chronic LBP.

To develop effective LBP treatment, we must clarify the relationship between LBP and motor control impairments; thus, the aim of this study was to determine whether impaired APRs could be improved using either STC or STB exercises. This is the first study to examine treatment's influence on the APR up to 6 months post-treatment. We predicted that STB treatment would result in increased trunk muscle activation and a multi-segmental postural response to perturbations post-treatment. We also predicted that STC treatment would increase trunk muscle strength and activation, but less specifically than STB, resulting in a rigid whole body postural response.

2. Methods

2.1. Subjects

Fifty-eight subjects met the inclusion criteria which were chronic, recurrent (Von Korff, 1994) LBP $\geq$ 6 months with an acute flare-up (McGorry et al., 2000), and current employment or active as a full-time student or homemaker. Subjects were excluded if they had: disc herniation, neurological signs, spinal or lower extremity disease, conditions or surgery, balance or cardiovascular disorders, a current pregnancy, involvement in litigation because of the LBP problem, or received worker's compensation for the LBP.

Subjects participated in a laboratory protocol and then were randomly assigned to treatment based on a covariate adaptive randomization scheme, with gender, age and smoking status as covariates (Pocock and Simon, 1975). Treatment assignments were transmitted to the study coordinator and the treating PT, neither of whom were masked to treatment; all other personnel were masked to treatment assignment. Thirty-eight subjects successfully completed the 10-week treatment program and returned for laboratory testing at 11weeks (Fig. 1). Of the 38 subjects, 13 subjects returned for the 6 month laboratory protocol. Assuming a Type I error rate of 5%, a sample size of 13 subjects/group would provide greater than 80% power to detect differences between groups of

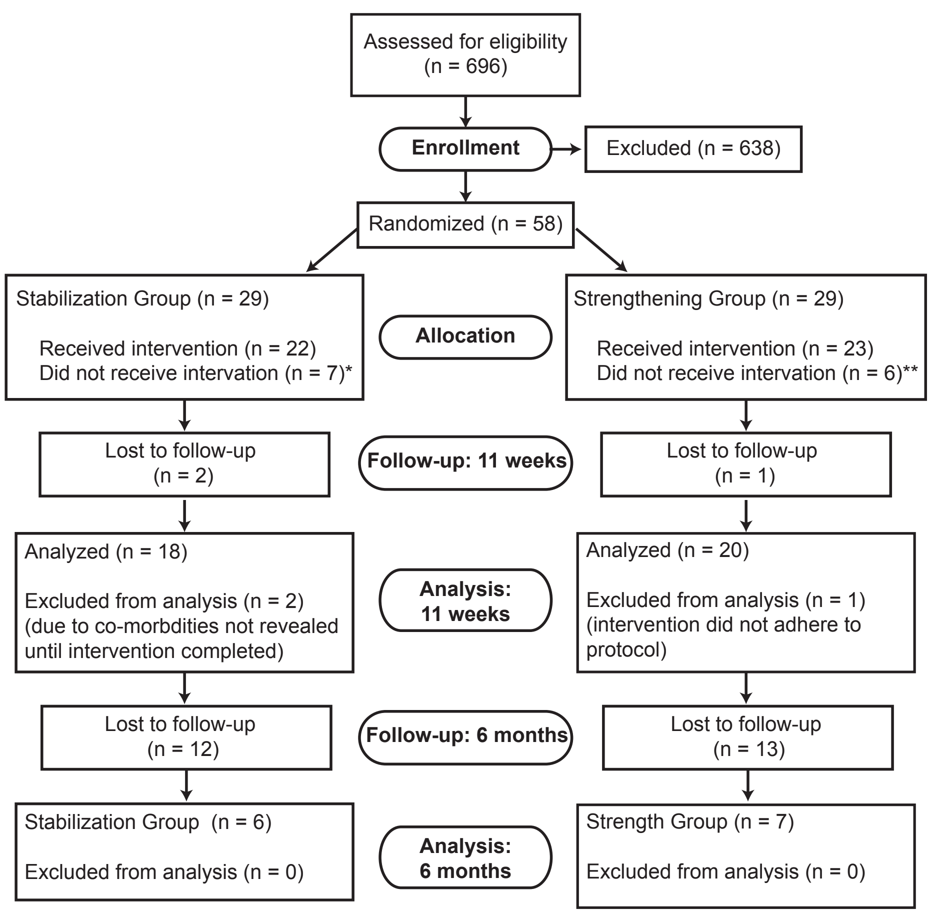

Fig. 1. Flow of subjects through recruitment, randomization and stage at which subjects were lost to follow-up for the STB group (*5 unable to schedule 10 consecutive appointments, 1 workers compensation claim, and 1 injured knee sustained outside of treatment) and STC group (**5 unable to schedule 10 consecutive appointments, and 1 broken collarbone sustained outside of treatment).

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