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Physical exercise reduces physical disability and psychological suffering in patients with chronic low back pain: a quasi-experimental study

Ejercicio físico reduce la discapacidade física y el sufrimento psicológico em pacientes con lumbalgia: un estudio cuasi experimental

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Abstract. The aim of this study was to evaluate the impact of segmental systemic stabilization in low back pain patients on the physical disability, psychological stress, and inflammatory profile of patients with Chronic Low Back Pain. We evaluated the effect of patients with Chronic Low Back Pain diagnosis (caused by spondylodiscoarthrosis and herniated lumbar disc) treated with segmental spine stabilization. Physical disability (performed by the Oswestry disability index), psychological distress (performed by patient health questionnaire-9) and concentrations of IL-1β, pro-inflammatory, and IL-10, anti-inflammatory, in the plasma and culture supernatant of peripheral blood mononuclear cells (PBMC) stimulated by lipopolysaccharide (LPS) (performed by ELISA) were evaluated before and at the end of the sessions of physiotherapy (16 sessions; twice a week with an average duration of 60 minutes). The patients with Chronic Low Back Pain who underwent spine stabilization exercises had a reduction of physical disability, psychological stress, an increase of IL-10 production and reduction of IL-1β production when compared to basal level. The regular practice of segmental spine stabilization exercises decreased physical disability, psychological distress, and inflammatory profile from adults with specific Chronic Low Back Pain diagnosis.

Key words: Physiotherapy; Physical exercise; Segmental spine stabilization; IL-1β; IL-10; Chronic pain.

Resumen. El objetivo de este estudio fue evaluar el impacto de la estabilización sistémica segmentaria en pacientes con lumbalgia sobre la discapacidad física, el estrés psicológico y el perfil inflamatorio de pacientes con dolor lumbar crónico. Se evaluó el efecto de pacientes con diagnóstico de lumbalgia crónica (causada por espondilodisartrosis y hernia de disco lumbar) tratados con estabilización segmentaria de columna. Incapacidad física (realizada por el índice de discapacidad de Oswestry), malestar psicológico (realizado por el cuestionario de salud del paciente-9) y concentraciones de IL-1β, proinflamatoria, e IL-10, antiinflamatorio, en plasma y sobrenadante de cultivo de células mononucleares de sangre periférica (PBMC) estimuladas por lipopolisacárido (LPS) (realizado por ELISA) antes y al final de las sesiones de fisioterapia (16 sesiones; dos veces por semana con una duración promedio de 60 minutos). Los pacientes con lumbalgia crónica que se sometieron a ejercicios de estabilización de la columna vertebral tuvieron una reducción de la discapacidad física, el estrés psicológico, un aumento de la producción de IL-10 y una reducción de la producción de IL-1β en comparación con el nivel basal. La prática regular de ejercicios de estabilización segmentaria de la columna disminuyó la discapacidad física, el malestar psicológico y el perfil inflamatorio de adultos con diagnóstico específico de lumbalgia crónica.

Palabras claves: Especialidad de Fisioterapia; Ejercicio Físico; IL-1β; IL-10; Dolor Crónico.

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Introduction

Chronic Low Back Pain (CLPB) is the most frequent and causes substantial suffering, decreased functional capacity, and lowers quality of life (Delitto et al., 2012; GBD Collaborators, 2018). The direct costs of chronic pain in the U.S. are estimated to be $100 billion or greater annually (Buchbinder et al., 2018; GBD 2017 Disease and Injury Incidence and Prevalence Collaborators, 2018). Most of the social and economic cost is attributed to people who have experienced and/or recurrent CLPB (Hartvigsen et al., 2018).

CLBP can be classified into as non-specific or specific**.** Specific CLBP occurs when an intrinsic or extrinsic cause of pain is diagnosed (Hayden et al., 2021; Malik et al., 2022). They are intrinsic causes: congenital, degenerative, inflammatory, infectious and tumor conditions. While the main extrinsic causes are the imbalance between the functional load, the effort required for work activities and/or daily life which generates postural stress as well as acute injuries causing deterioration of structures due to CLPB (Hayden et al., 2021; Malik et al., 2022).

The most common causes of specific CLBP are spinal degeneration due to spondylodiscoarthrosis and herniated lumbar disc. A recent narrative review sought evaluate the relationship between low back pain in athletes who practice sports that envolve strenght. Although with a more differenciated approach, they indicate the need for studies that address the prevention of low back pain (Baraldo et al., 2023).

Studies have emphasized the psychosocial influence on the development of chronicity and the persistence of CLPB complaints (Nicholas et al., 2019; Wong et al., 2017). Increased distress accompanies more severe pain, enhances pain-related disability, and contributes to the development of the chronicity of low back pain (Buchbinder et al., 2018; Hartvigsen et al., 2018).

Patients with chronic pain reported poorer self-perceived health than those without pain, showed higher psychological distress, and had a greater number of chronic comorbidities (Nicholas et al., 2019), like several biopsychosocial factors associated with CLBP, such as

psychological distress conditions (Wong et al., 2017).

Physical exercise protocol such as kinesiotherapy, could be an important strategy to manage and treat CLBP, and is the most widely recommended conservative treatment improving the quality of life of these patients (Hayden et al., 2021; Vadalà et al., 2020). The influence of physical training on immune responses such as circulating cytokines is widely known (Campbell & Turner, 2018; Docherty et al., 2022).

Exercise is an important strategy that can be used to manage and treat CLBP and is the most widely recommended conservative treatment for this population (Hayden et al., 2021; Vadalà et al., 2020). Different exercise protocols are used, including those involving segmental stabilization and strengthening of the trunk extensor which have been shown to reduce CLBP symptoms (Airaksinen et al., 2006; George et al., 2021).

For example, segmental spine stabilization exercises involving abdominal bracing and strengthening of the abdominal and lumbar musculature and had significant gains for pain and functional disability that stretch and strengthen the deep and superficial muscles (Nascimento et al., 2018; Soundararajan & Thankappan, 2017).

The purpose of this study was to evaluate the effect of the regular practice of segmental stabilization exercise on disability; psychological distress; and inflammatory profile of adults specific CLBP (caused by spondylodiscoarthrosis and herniated lumbar disc) diagnosis.

Materials and Methods

This is a quasi-experimental study; data for this longitudinal study was obtained from a larger experimental study that assessed the effectiveness of segmental spine stabilization treatment in relieving CLBP in adults.

Participants

Patients seeking treatment for CLBP at a physical therapy clinic were screened for study eligibility by a physiotherapist. All patients were referred for physiotherapy by a physician; therefore, this setting was considered secondary care. The potential study participants following criteria before being enrolled into this study: 1) adults between the ages of 18 and 60 seeking physiotherapy for CLBP (defined as having symptoms at T12 or lower, including radiating pain into the buttocks and lower extremity) and 2) the ability to read and speak the Portuguese language.

We included only CLBP patients based on the current self-reported symptom duration that is greater than or equal to 91 days. The potential study participants were ineligible to participate in this study if any of the following criteria were met: 1) presence of systemic involvement related to metastatic or visceral disease; 2) recent spinal fracture; or 3) pregnancy; 4) autoimmune or infectious diseases.

The physiotherapists provided all the patients that met study eligibility criteria with a brief explanation of the study. The clinicians emphasized to the patients that participating in this study would not dictate the treatment they received for their CLBP and that if they elected not to participate, they would receive the same treatment. This study was approved by the Federal University of Triângulo Mineiro Ethics Committee for Research with humans (under protocol number 5154), according to the guidelines proposed in resolution 196/96 of the National Health Council, and the informed consent was obtained from each studied participant.

Demographic and Historical Variables

The participants answered a standardized self-report questionnaire consisting of demographic items related to age, gender, race, and employment status before the start the study. Additionally, information involving CLBP clinical characteristics (i.e., prior surgery, symptom duration, symptom onset, symptom location) was obtained.

Intervention

The patients underwent two weekly sessions of physiotherapy with an average duration of 60 minutes, for a total of 16 sessions. The patients were submitted to segmental spine stabilization (KG group) (Kisner & Colby, 2009) (Figure 1).

Blood pressure levels were measured at the beginning of each session to ensure that they were normal. The patients attended two sessions in which they were instructed on how to perform the exercises and were made aware of the importance of maintaining contraction of the transversus abdominis on segmental spine stabilization exercises in a series of ten repetitions and in the las seven sessions they performed two series of ten repetitions.

Clinical Measure

Oswestry Disability Index (ODI). The ODI 2.0 test was used for functional assessment of the lumbar spine; it incorporates measures of pai and physical activity. The test consists of 10 questions with six possible answers, with values ranging from 0 to 5. The total score is divided by the number of answered questions multiplied by 5, and the result of this division is multiplied by 100, with the final value presented as a percentage. The ODI score is rated as minimal disability (0-20%), moderate disability (21-40%), severe disability (41-60%), disability (61-80%), or bedridden (81-100%) (Nascimento et al., 2018).

Psychological Measure

The Psychological Distress Patient Health Questionnaire (PHQ-9) is a tool for rapid assessment of depression. It includes 10 questions with scores ranging 0 to 3, with a total maximum score of 30 points. Values ≥ 9 indicate individuals with a higher risk of being in a depressed condition. This test does not exclude the need for evaluation by a psychiatrist (Pergolizzi & LeQuang, 2020) and/or a psychologist and has been used in studies involving with CLBP (Tao et al., 2017).

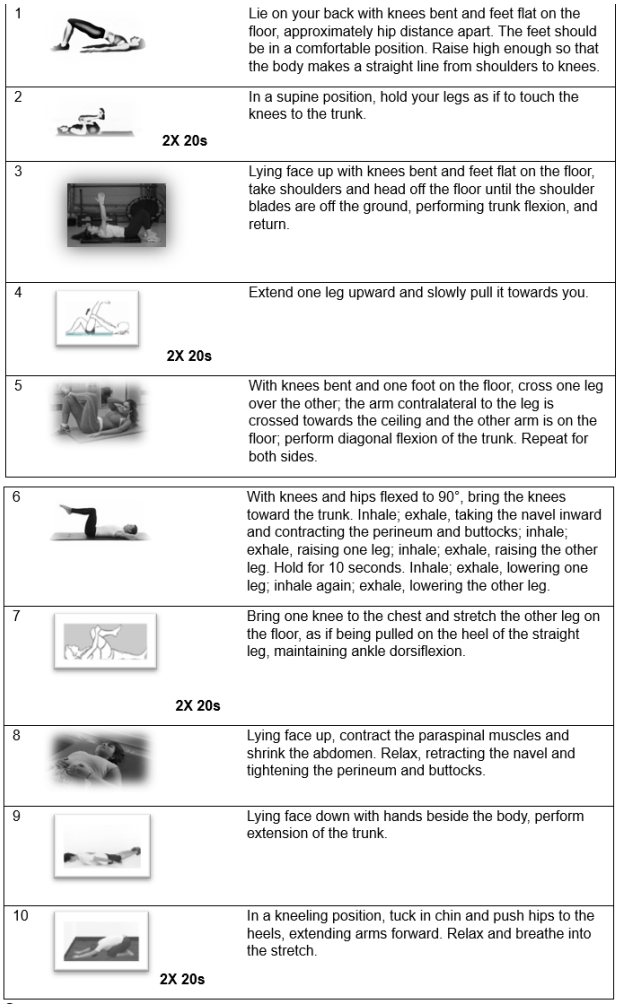

Figure 1. Sequence of segmental spine stabilization exercises. Source: Kisner, Colby, (2009)

Blood Collection, Cell Isolation and Culture

Peripheral blood (10-20 mL) from patients was drawn in heparinized tubes. All the blood was treated immediately for isolation of blood cells and separation of plasma (which was stored at a -80 °C until measurement). The PBMCs were isolated by density-gradient centrifugation over Histopaque 1077 (Sigma Aldrich). RPMI 1640 supplemented with 10% fetal bovine plasma, 2 mL glutamine, 100 U/mL penicillin, and 100 μg/mL streptomycin was used as the complete culture medium for further analysis (Hohenschurz-Schmidt et al., 2020).

PBMCs (1 x 10^6 cell/mL) from patients were cultivated in 96-well plates and stimulated or not with lipopolysaccharides (LPS) (1 μg/mL). The supernatant was collected 24 hours after LPS stimulation (Murphy et al., 2014).

IL-1β and IL-10 production.

IL-1β and IL-10 concentrations in the plasma and supernatants of the PBMCs were determined by ELISA according to the manufacturer's instructions (R & D Systems, or BD Pharmingen) (Timóteo et al., 2016).

Data Analysis

The results were expressed as the mean ± standard error of the mean. The analysis of the demographic variables and clinical measures were performed using SPSS, Version 20.0.

The evaluation of the results from cytokines was performed by analysis of variance (ANOVA) followed by a Tukey's post-hoc test. P values <0.05 were considered statistically significant.

Results

Participants

In total, 14 patients were screened for eligibility. Table 1 shows the sociodemographic and clinical characteristics of the patients at baseline. A strong association between the disability and depression was found, with significant levels of p ≤ 0.03 (KG) in this study sample (Table 1).

Table 1.
Descriptive statistics for study sample.

Variable	KG, (n=14)
Gender	M: 63%; F: 37%
Age (years old)	53 (4)
Education (years)	5 (4)
Symptom duration (years)	3 (4)
PHQ-9 (range: 0-27)	13 (6)
ODI (range: 0-100%)	40% (13%)
Spearman correlation (ODI/PHQ-9)	0.03
IL-1β (pg/mL; plasma)	41,75 (20)
IL-10 (pg/mL; plasma)	0
IL-1β (pg/mL; PBMCs unstimulated)	54,17 (23.2)
PBMCs IL-10 (pg/mL; PBMCs unstimulated)	16,95 (11)
IL-1β (pg/mL; LPS-stimulated PBMCs)	125,65 (37.3)
IL-10 (pg/mL; LPS-stimulated PBMCs)	15 (9.8)
Treatment sessions	16

Values expressed as means, with standard deviations in parentheses; 95% confidence intervals with p values (≤ 0.05); M: male: F: female; PHQ-9: Patient Health Questionnaire (9-item version); ODI: Oswestry Disability Index; PBMCs: peripheral blood mononuclear cells.

For the primary outcome, physical disability after 16 sessions showed a significant difference (p = 0.002) when compared to the scores before and after the intervention (Table 2). For the psychological distress after 16 sessions showed a significant difference (p = 0.005) when compared to the scores before and after the intervention (Table 2).

Table 2.
Comparison of before and after intervention.

	Before			After			
	Mean (SD)	Minimum	Maximum	Mean (SD)	Minimum	Maximum	*p*
ODI	36 (12.6)	24	66	24 (13)	4	50	.002
PHQ-9	12 (5.6)	6	24	7.2 (6.2)	0	19	.005

95% confidence intervals with p values (≤ 0.05); statistically significant p values in bold; SD: standard deviation; PHQ-9: Patient Health Questionnaire (9-item version); ODI: Oswestry Disability Index.

The results of the spine stabilization exercises were also evaluated through analysis of cytokines IL-1β (pro-inflammatory) and IL-10 (anti-inflammatory) as in plasma as PBMCs stimulated by LPS. The IL-10 production was increased (~31 folds) in the plasma of patients with CLBP who underwent spine stabilization exercises compared to the baseline level (Figure 2B). No significant alteration was observed in the IL-1β concentrations between the groups.

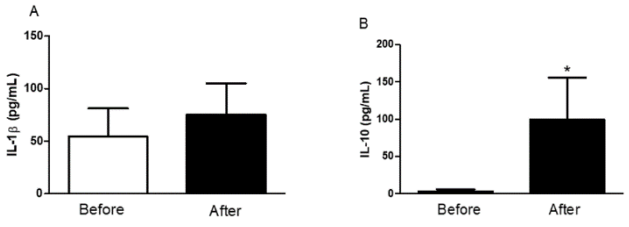

Figure 2. Segmental spine stabilization increased the IL-10 production in plasma samples from patients with chronic low back pain. The plasma samples were collected before and after 16 physical therapy sessions in group with segmental spine stabilization. IL-1β (A) and IL-10 (B) concentrations were measured by ELISA kit. The data are reported as the means ± SEM (n=5-13). *p < 0.05 versus before therapy.

LPS induced the increased of IL-1β production (Figure 3A), without alteration of IL-10 concentration (Figure 3B), in the PBMCs from patients before exercise when compared to non-stimulated cells. Interesting, the IL-1β productions in the LPS-stimulated PBMCs from patients with CLBP who underwent spine stabilization exercises was reduced (~93%) while the IL-10 production was increased (~9 folds) (Figure 3B) when compared to LPS-stimulated PBMCs from patients before exercises.

In addition, the IL-10 production of in the LPS-stimulated PBMCs from patients with CLBP who underwent spine stabilization exercises was increased (~47 folds) when compared to non-stimulated cells.

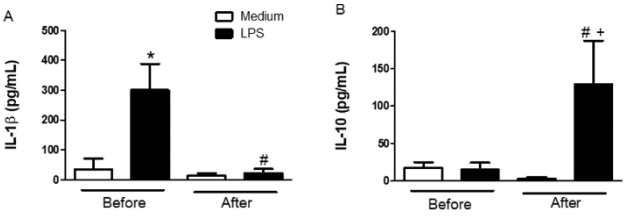

Figure 3. Segmental spine stabilization demonstrated anti-inflammatory effects by decreasing IL-1β and increased IL-10 productions in PBMCs from patients with chronic low back pain stimulated with LPS. PBMCs were collected before and after 16 physical therapy sessions in group with segmental spine stabilization. PBMCs were stimulated or not with LPS (1 μg/mL). At 24 h after stimulation, the culture supernatants were collected to determine the concentrations of IL-1β (A) and IL-10 (B) using an ELISA kit. Data are reported as means ± SEM (n=5-12/group). *p < 0.05 medium before treatment, #p < 0.05 versus LPS before treatment. +p < 0.05 versus medium after treatment.

Discussion

The regular practice of segmental spine stabilization exercises decreased physical disability, psychological distress, and inflammatory profile from adults with specific CLBP diagnosis.

The results of physical disability agreed (George et al., 2021), which noted that there is not ideal form of exercise to rehabilitate patients with CLBP, with combinations of techniques generally being employed in rehabilitation and training (Airaksinen et al., 2006; Shamji et al., 2010). Exercise is likely to be effective in treating chronic LBP compared with no treatment, usual care, or placebo (Hayden et al., 2021). Compared to other conservative treatments, exercise had better result in terms of pain and functional limitations (Hayden et al., 2021).

The findings about psychological distress agreed other studies (Airaksinen et al., 2006; George et al., 2021; Wong et al., 2017). Metal health symptoms are strongly linked with CLBP and people with mental health symptoms, such as depressive symptoms or anxiety, have poorer recovery from LBP (Wong et al., 2017) but a group-based education/exercise programme proved effective in terms of decreasing pain, improving physical function, and improving psychosocial status (Prado et al., 2021; Soundararajan & Thankappan, 2017).

However, we must make it clear that patients with CLPB, when undergoing any intervention, can benefit from some placebo effects such as the expectation and/or possibility of having a personalized treatment with frequent monitoring, hope of obtaining better results with the treatment and good communication, between healthcare professional and patients. (Ballestra et al., 2022).

The peripheral and systemic inflammations are linked to the development and persistence of many pain disorders. Pro-inflammatory cytokines coordinate and amplify the inflammatory response as well as induce the releasing of neurotrophic factors that contribute to, he pathophysiology of pain associated with peripheral and central nociception (Lobo-Silva et al., 2016; Schroeder et al., 2013).

Many pro-inflammatory cytokines such as IL-1β are elevated in CLBP (Hung et al., 2017; Kwilasz et al., 2015). Increased concentrations of IL-1β were associated with matrix degradation, innervation, and nociception (Kwilasz et al., 2015; Vanderwall & Milligan, 2019). So, the control of IL-1β production is desirable for blocking the persistent inflammatory responses as well as the sensations of pain.

On the other hand, IL-10 is generally known as an anti-inflammatory cytokine that exerts a plethora of immunomodulatory functions (such as inhibiting the synthesis of pro-inflammatory cytokines and reducing the activation and effector functions of T cells, monocytes, and macrophages) ending the inflammatory response to injury (Lobo-Silva et al., 2016).

IL-10 decreased the injury damage and signs of neuroinflammation. In both neuropathic pain patients and in animal models of neuropathic pain, the IL-10 concentrations are decreased compared to the controls (Hung et al., 2017; Kwilasz et al., 2015).

Different methods have been used for evaluation and intervention in patientes with CLBP, such as ultrasonographic measurement (Sánchez Romero et al., 2021), surface electromyography (Fernandes et al., 2018) dynamometer (Dos Santos et al., 2017; Sipaviciene & Kliziene, 2020; Kazemkhani et al., 2022), among other approaches (Santos et al., 2019; Ahmadnezhad et al., 2020). There is no information in the literature about the effect of segmental spine stabilization in the immunological system and its benefits for patients with LBP. In this way, our results are the first to demonstrate the immunomodulatory effects of segmental spine stabilization in the immune system and mainly their

benefits in (CLBP) patients.

Our work also presents different exercises that can be performed with body weight with little or no necessary material, thus showing the importance of the protocol that practitioners underwent. Health professionals who treat CLPB can use this protocol anywhere in a practical way, enabling it to be effective in reducing disability and suffering. On the other hand, this work does not present a control group, which does not allow us to see the real effect of the protocol to which the practitioners were subjected, which becomes a limitation.

Conclusions

The supervised physical exercises segmental spine stabilization was effective in reducing physical disability, improving psychological distress, and enhancing the endogenous anti-inflammatory mechanisms of patients with chronic LBP, reducing pain symptoms and increasing quality of life.

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