

The model of movement rehabilitation for trunk stabilization in physiotherapy treatment

LILI ŠILER¹, MAG. PT, ASSOC. PROF. DR. FRIDERIKA KRESAL¹

¹Institution of Higher Education for Physiotherapy, Slovenska cesta 58, SI - 1000 Ljubljana

Correspondence: izr. prof. dr. FRIDERIKA KRESAL

e mail: friderika.kresal@fizioterapevtika.si

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Abstract

The significance of the core function of the body in stabilizing and generating force during daily activities is gaining greater recognition. Trunk stabilization exercises (TSE) play a crucial role in activating and strengthening the core muscles, which are responsible for spinal stabilization and are considered a key element in restoring proper kinetic movement. Therefore, our objective is to explore evidence-based models of movement rehabilitation for trunk stabilization in physiotherapy treatments. TSE represents a viable option for strengthening trunk muscles within a well-designed rehabilitation program that considers other essential parameters to achieve favorable rehabilitation outcomes.

Model gibalne rehabilitacije pri stabilizaciji trupa v fizioterapevtski obravnavi

Povzetek

Pomembnost funkcije jedra telesa, za stabilizacijo in proizvodnjo sil pri opravljanju vsakodnevnih aktivnosti, postaja vse bolj prepoznavna. Vadba za stabilizacijo trupa (VST) aktivira in krepi mišice jedra, ki so odgovorne za stabilizacijo hrbtenice in veljajo za ključni element pri obnovi pravilnega kinetičnega gibanja, zato je naš namen proučiti z dokazi podprte modele gibalne rehabilitacije pri stabilizaciji trupa v fizioterapevtski obravnavi. VST predstavljajo eno izmed možnosti krepitve mišic trupa v kakovostno načrtovanem rehabilitacijskem programu, ki upošteva tudi druge pomembne parametre za doseg učinkovitejšega rehabilitacijskega izida.

INTRODUCTION

The significance of the body's core function in stabilizing and generating force for everyday activities is increasingly acknowledged. The core, comprising central muscles, plays a pivotal role in maintaining stability during various locomotor tasks involving the arms and legs. It provides support for demanding actions, acting as the center of strength from which we draw power for other movements.

A strong core is essential, as reduced trunk strength is associated with both low back pain and lower limb injuries (Nation, 2015). The spinal stabilization system, composed of three subsystems, serves to facilitate movement between body segments, bear loads, and protect the spinal cord. The passive musculoskeletal system, including vertebrae, intervertebral discs, ligaments, and joint capsules, ensures spine stability during movement. However, the active subsystem, comprising muscles and tendons, plays a vital role and works in coordination with the passive structures to guarantee spinal stability (Panjabi, 1992).

Studies on cadavers demonstrate that removing muscles leads to spinal deformities, even under minor loads (9 kg) (Crisco & Panjabi, 1992). However, minimal muscle coactivation is generally sufficient to maintain segmental stability under normal conditions (S. M. McGill, 2001).

From a mechanical perspective, Bergmark (1989) introduced the concept of global and local muscles in the active spinal subsystem. The global muscles, including the m. erector spinae, m. obliquus externus abdominis, m. obliquus internus abdominis, m. rectus abdominis, and the outer part of m. quadratus lumborum (QL), transmit forces between the thorax and pelvis. These muscles have longer arms and larger cross-sections, making them ideal for generating greater muscle force (Arokoski et al., 2001).

On the other hand, the local muscles, such as m. multifidus, m. interspinales lumborum, and m. intertransversarii lumborum, originate or attach to the lumbar vertebrae. They control neutral curvature (Comerford & Mottram, 2001), intersegmental movement, and provide mechanical stiffness. These muscles mainly undergo isometric contractions, rapidly activating and independent of the type of movement, except for the deeper hip flexor, the psoas muscle (Bergmark, 1989).

Trunk stabilization exercises aim to achieve a balanced muscular state in the spinal-pelvic region (Misirlioğlu et al., 2018). A comprehensive movement therapy program should consider both dynamic and static muscle force production. Core strengthening involves activating the trunk musculature, leading to improved body biomechanics in various sports and daily activities. Insufficient core muscle coordination may result in compensatory patterns and overload syndromes (Abt et al., 2007; Akuthota & Nadler, 2004; Hibbs et al., 2011; S. McGill, 2015). Muscle strength and coordination are critical factors for spine protection, particularly against dangerous shear forces (McGill, 2007).

When a limb moves, reactive forces parallel and opposite to the movement's causing forces are applied to the spine. The multi-segmental nature of the spine and the need for muscle contraction to ensure stability make it highly sensitive to these reactive forces. Even as little as 2° of rotation can cause significant micro-injury to the lumbar spine, emphasizing the importance of muscular control during limb movement (Briggs et al., 2004; Cholewicki & McGill, 1996).

The training goal should encompass not only static muscle strength but also dynamic strength and, importantly, flexibility. When focusing on trunk stabilization, it is crucial to consider pelvic stability and ensure its correct position. Lower limb movements originate from or influence the pelvis, making pelvic stability essential for the effective dynamic execution of these movements (Lee & Hodges, 2004).

A comprehensive kinesiotherapeutic approach should prioritize spinal stability, muscle strength, and endurance before integrating trunk flexibility training (Šarabon et al., 2011). Successful exercise rehabilitation programs emphasize maintaining trunk stability through exercises that keep the spine in a neutral position while performing movements at the knees and hips (Cholewicki et al., 1991; Hides et al., 2001).

The movement therapy model for trunk stabilization should follow a stepwise approach. Firstly, patients should learn to achieve neutral lordosis. Subsequently, they can progress to activating the local muscle system under stable conditions and finally move to the phase of activating the local muscle system under dynamic conditions (O'Sullivan, 2000).

It's crucial to prevent functional abnormalities in human posture resulting from repeated unilateral loading of a healthy musculoskeletal system. Therefore, exercise therapy must focus on appropriately selecting content to ensure the harmonious development of strength and flexibility in all muscle groups (Šarabon et al., 2011).

METHODS

The research conducted was based on a descriptive method, utilizing professional and scientific literature in both English and Slovenian from the period between 1990 and 2021. The data were obtained through an extensive search of various databases, including Web of Science, Medline, PubMed, ScienceDirect, PEDRO, and Google Scholar. Titles, abstracts, and full-text articles were screened to meet the selection criteria, and reference lists were also reviewed for additional relevant studies.

To ensure internal validity, specific inclusion and exclusion criteria were established at the beginning of the systematic review. Boolean AND and OR operators were used to logically combine search terms, creating a complex search profile to narrow or broaden the search. The research focused on keywords such as lumbar stabilization, core stabilization, core exercise, core strengthening, lumbopelvic stability, postural stability, abdominal muscles, transversus abdominis, low back pain, chronic low back pain, and LBP.

Eligible studies were selected based on certain criteria, including adult participants of both genders with back pain, interventions involving trunk-stabilizing exercises lasting at least two weeks, comparison with other active exercises, manual therapy, or conventional physiotherapy, and observed outcomes related to lumbar stability, pain, strength, and endurance of trunk stabilizers. Studies in other languages, non-randomized control studies, those without clear results or unavailable full-text articles, and studies published before 1990 were excluded from the analysis.

RESULTS

The systematic review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Moher et al., 2010). Using the selected keywords, we retrieved 2,773 studies from various databases, ultimately considering 49 for full-text review. After the full-text review, we excluded 32 articles for reasons such as not meeting participant criteria, intervention criteria, study design, result duplication, or lacking relevant endpoints. Ultimately, 17 studies met our inclusion and exclusion criteria for analysis.

These 17 studies focused on assessing the impact of Core Stabilization Exercises (CSE) on Low Back Pain (LBP). The sample size included 1,405 subjects with an average age of 43.09 years. Individual study sample sizes ranged from 20 to 240 subjects, with an average of 82.6 subjects. The majority of participants were female (56.7%), while one study included only men, and three studies had a higher male ratio. In three studies, the male-to-female ratio was not recorded. Various measurement tools were used in the studies, including VAS, NPRS, PSFS, ODI, RMDQ, GPE, ST, SF-36, HRQOL, KWT, and STS, to assess pain intensity, functional capacity, disability, health-related quality of life, and trunk endurance.

The studies included individuals with LBP lasting between 8 and a maximum of 44 weeks, with one study not specifying the duration of pain. All the included studies were randomized controlled trials (RCTs) and provided valuable insights into the effects of Core Stabilization Exercises on Low Back Pain. The studies are identified by author, methodological characteristics, participant characteristics, main results, and conclusions.

DISCUSSION

Lumbar spine or lumbosacral spine instability is a common observation among individuals with Low Back Pain (LBP) (Friberg, 1987). While several therapeutic procedures aim to alleviate instability, many lack strong scientific evidence, resulting in a variety of strategies employed to address LBP. Possible factors contributing to this confusion include the absence of clear clinical guidelines based on evidence-based

practice, ignorance or rejection of existing scientific evidence, strong adherence to specific therapeutic approaches, or underestimation of the effectiveness of competing therapeutic methods.

The research question seeking to identify the most important parameters for motor rehabilitation in trunk stabilization does not yield clear answers from existing studies. Although all 17 studies generally concur on the positive effects of Core Stabilization Exercises (CSE) in reducing pain, improving functional disability, enhancing satisfaction, quality of life, endurance, and trunk muscle stability, they do not offer definitive parameters for motor rehabilitation. Moreover, CSE appears to be similarly effective as other exercise approaches, suggesting no clear evidence supporting its superiority over alternative strategies. The term 'core stability' lacks a precise linguistic connection to motion and primarily emerged in the context of using CSE for low back pain treatment (Hodges, 1999). Some researchers caution against using the term 'trunk stabilization' due to its vagueness and potential for various interpretations. They suggest that it should be further clarified or potentially replaced. Terms like 'motor control training' and 'stabilization exercises' are often used interchangeably. Motor control training, as per McNeil (2010), typically refers to local joint stabilization. Brummit et al. (2013) aimed to review approaches to rehabilitation training for motor control in patients with LBP, but their literature search focused on segmental stabilization. Unlike other terms for motor control training, such as neuromuscular control or neuromotor control, 'core stability' or 'stabilization exercises' do not inherently imply a role for the nervous system in movement control.

The concept of Core Stabilization Exercises (CSE) is closely linked to the relationship between chronic Low Back Pain (LBP) and lumbar instability, as well as the connection between muscle imbalance and LBP (Stuge, 2019). However, the terms 'core stability' or 'stabilization exercises' do not inherently imply the involvement of the nervous system in movement control, which is considered crucial according to Panjabi's model of stability (Panjabi, 1992b). The lack of clear definitions of movement strategies in the studies has led to ambiguous conclusions, underscoring the need for further research and precise definitions to establish clearer guidelines for motor rehabilitation in trunk stabilization.

The review's findings suggest that CSE targeting deep abdominal muscles, without considering the potential neuroplasticity of the nervous system, may not yield the desired results (Macedo et al., 2012). These exercises aim to activate central muscles in more complex and functional tasks, which can be enhanced through implicit and explicit learning. Explicit learning progresses in motor learning from the verbal-cognitive phase to the autonomous phase, while implicit learning involves the direct acquisition of procedural knowledge without memory processing (Kal et al., 2013; Kleynen et al., 2014).

Intervention periods in the studies varied from 4 to 12 weeks, with an average of 7 weeks. However, this duration may still be insufficient, considering research that recommends progressive exercise over time (Cairns et al., 2006). Reducing the heterogeneity of intervention periods could enhance the level of evidence on the effects of CSE, enabling the establishment of structured exercise recommendations and determining the appropriate dose-effect relationship for physical rehabilitation (Mueller & Niederer, 2020).

The frequency of treatments per week ranged up to 3.2 times, and cortical changes typically require numerous repetitions of movements in different contexts (van Vliet et al., 2012). Nonetheless, research indicates that precise execution of movement components may be more effective than merely repeating sequences of movement activities (Boudreau et al., 2010). Thus, the importance of quality and precision in exercise execution should not be overlooked when considering the effectiveness of CSE and its impact on neuroplasticity.

In the included studies, general exercise was the most common comparator intervention, but the term "general exercise" is imprecise as it can encompass various types of exercises (Macedo et al., 2008). These exercises often include flexion, extension, and stretching exercises, either alone or in combination. General exercises have shown to be effective in managing non-specific LBP, producing reductions in pain, improved work capacity, increased functionality, and reduced depression and fear of pain. The results are comparable to those of CSE, especially in the long term, though CSE may show more short-term effects in pain reduction. However, the credibility of the final results in some studies is affected by a limited number of participants, and more consistent descriptions of exercise parameters are needed.

In the context of a biopsychosocial perspective, exercise prescription for LBP should consider psychological and physical factors, and exercise needs to be individualized to the specific needs and abilities of the individual. The type of exercise, dosage, frequency, duration, intensity, quality, and delivery should all be tailored to the individual, and patient participation and motivation are crucial for successful outcomes in physical rehabilitation (Stuge, 2019). Encouraging patient participation and integrating their preferences with self-defined movement goals can facilitate behavior change and adherence to exercise programs. Additionally, supervised exercises in the home environment with feedback on performance and correction of movement patterns are essential components of effective rehabilitation.

Assessing trunk stability is crucial when prescribing Core Stabilization Exercises (CSE). A study by Waldhelm (2011) compared 35 tests that assessed five different components of trunk stability: strength, endurance, flexibility, motor control, and function. The tests within each group showed high reliability, with endurance tests being the most reliable, followed by flexibility, strength, motor control, and function (Waldhelm, 2011). However, in many studies within the systematic review, there was a lack of comprehensive tests to assess trunk stability. These studies were primarily focused on demonstrating the effects of the exercises rather than organizing the performances based on testing.

To achieve a stable trunk without Low Back Pain (LBP), the muscles must increase their cross-section. However, in CSE, the contractions of the trunk stabilizers are generally below 70 percent of the maximum contraction required for muscle hypertrophy (de Souza et al., 2012). For instance, a 4-week CSE study on back muscle fatigue in chronic LBP did not lead to improved muscle endurance (Sung, 2013). Different techniques, such as the abdominal draw-in maneuver, abdominal muscle tensing, and posterior pelvic tilt, can activate the abdominal muscles and the multifidus muscles during stabilization. Research has shown that the abdominal draw-in maneuver, which involves exhalation and simultaneously drawing the navel towards the spine without pelvic displacement, has a greater effect on the Transversus Abdominis and multifidus activation than the other techniques (P. Hodges et al., 1996). This maneuver also increases intra-abdominal pressure (Kisner & Colby, 2007).

The methodological quality of some studies in the review was generally poor, leading to a high potential for bias. Double-blind randomized placebo-controlled trials involving patients and healthcare professionals were not adequately conducted in some cases. Further research should focus on specific subgroups within the LBP population and be thoroughly described. Different subgroups of patients with LBP may respond differently to various types of exercise, but it remains unclear which patients benefit most from a particular approach. Moreover, more research is needed to examine different forms of exercise approaches, and their descriptions should include details about adherence and concurrent interventions.

Individualizing a specific exercise program for patients with LBP requires appropriate expert guidance and supervision. The need for expert guidance and supervision is supported by the observation that adherence to prescribed exercise tends to be poorer in individuals with LBP. This underscores the importance of professional supervision to ensure the correct execution and adherence to the prescribed exercises for better outcomes in trunk stabilization and LBP management.

CONCLUSIONS

Trunk stabilization exercises have been widely used for rehabilitation, prevention, and improving athletic performance. However, this widespread use has led to varying interpretations of what trunk stabilization entails and which muscles are involved. Core strengthening has a solid theoretical foundation for treating and preventing low back pain and other musculoskeletal disorders, supported by its widespread clinical application. Research has demonstrated that these programs can effectively relieve pain and enhance trunk stability in patients with low back pain. Trunk stabilization depends on the integration of passive, active, and neural control subsystems. Core muscles are functionally classified based on their stabilizing or mobilizing roles, and neuromuscular control is crucial for coordinating this complex dynamic stabilization system. Properly learned movement patterns through movement therapy training automatically protect the spine from disturbances and increase the range of movement programs with appropriate stabilization responses.

While some studies on core strengthening show conflicting results, the number of studies in this area is limited. Future research should develop specific core strengthening programs and examine their effects on the treatment and prevention of low back pain compared to other exercise programs. The success of treating low back pain lies in accurately identifying subgroups of the population that respond well to specific exercise interventions. An individualized exercise approach, targeted at improving optimal segmental control of the spine for patients with lumbar segment instability, is a logical treatment strategy for this condition. The success of this approach depends on the skill of the physiotherapist in accurately identifying the clinical problem and the specific motor control impairment, as well as facilitating the correction of incorrect movement patterns. Additionally, incorporating functional movement patterns tailored to the specific movement needs of the workplace or sport into the movement therapy program is crucial. Developing appropriate tests for trunk stability will also be necessary.

Although there may never be a perfect program that meets all expectations, it is vital to follow scientific findings, critically evaluate them, and not solely rely on pre-existing programs. A holistic approach to patient treatment should be implemented, considering the individual's needs beyond just trunk stabilization. This approach should only be carried out by professionals with the appropriate qualifications and expertise.

In conclusion, core stabilization exercises represent an evolving field, and clinical rehabilitation strategies are continually being developed and refined. Modern core stability programs typically address two main exercise strategies: motor control and muscular performance. Both strategies are well-supported in the literature and should be viewed as complementary rather than opposing approaches to exercise training. It is essential to recognize the clinical effectiveness of these approaches through rigorous clinical trials.

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