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# Muscles training for the stability of the spine

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**Abstract**

**The aim of the paper is to review various opinions regarding the role of training dedicated to specific muscles in maintaining stability of the spine. Insufficient performance of trunk muscles and resultant changes in motor control lead to decreased stability of spinal segments and unfavorable shift in the distribution of loads in this body region. Disproportion in the strength of trunk muscles in adults is responsible for age-related changes in their body posture. Abdominal muscles are postulated to play particularly important role in postural control and inappropriate tone thereof is considered an etiological factor of back pain. Although a large number of training programs for trunk muscles exists, not all exercises are suitable for individuals of various age, physical fitness and health status. During recent decade, the so-called core stability exercises have been raising a growing interest as a method for spinal stability improvement. The exercises that improve one's ability to maintain correct body posture at rest and during complex coordinated movements are increasingly recommended by therapists, rather than those aimed solely at the strength gain. A growing body of evidence points to the effectiveness of exercises involving the so-called "abdominal bracing", i.e. maximal activation of the whole muscular "girdle" of the lower trunk without hollowing the lower abdomen and in a neutral-spine position, causes problem in the control of back pain. Conclusion. Available evidence suggests that it is "abdominal bracing" which constitutes an optimal solution for individuals who suffer from back pain.**

**KEYWORDS: spine, pain, exercise, abdominal muscles.**

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## Introduction

Insufficient performance of trunk muscles and resultant changes in motor control lead to decreased stability of spinal segments and unfavorable shift in the distribution of loads in this body region [20]. Disproportion in the strength of trunk muscles in adults is responsible for age-related changes in their body posture.

Abdominal muscles are postulated to play particularly important role in postural control; weakening thereof and/or excessive loss of muscle tone are considered to be principal risk factors for diminished quality of life. Weaker abdominal muscles not only may constitute the cause of distress related to less attractive silhouette, but also contribute to back pain, a relatively frequent complaint of contemporary, physically inactive, human beings [27]. Back pain is one from the most frequent health problems and of occupational diseases [38, 33]. It is estimated that ca. 90% of back pain cases have multifactorial and complex etiology [20]; however, the risk for back pain is also known to increase with waist circumference, overweight and lesser capacity of abdominal muscles. These unfavorable age-related changes in human body stimulated research on exercises that may restore "flat belly" and eliminate back pain.

### *Training and back pain*

Paradoxically, back pain affects also many athletes who unlikely present with weak trunk muscles. In one study, approximately 68% of athletes practicing various disciplines reported back pain within a year preceding the survey [31]. In contrast, individuals who do not practice any sport significantly less often complain on

back pain. Obviously, the principal reason behind this phenomenon is spinal overload, occurring frequently in elite athletes. However, sportspersons should theoretically be at lower risk for this pathology due to regular training of their muscles.

*Selection of training method and spinal performance*

A number of more or less elaborated training programs for trunk muscles have been described in literature [10]. However, not all exercises included in such programs are necessarily suitable for all individuals of different age, physical fitness and health status. Norris [44] analyzed mechanics of several exercises for abdominal muscles and concluded that training programs for this muscle group should be adjusted for the needs and capability of the individuals. The same exercise may be beneficial for one person but harmful for another.

The need for training individualization is not associated solely with differences in the type of exercises undertaken during practicing sports and occupational activities, but also with age-related changes. Studies using magnetic resonance imaging (MRI) demonstrated greater atrophy in the spinal extensors than in the spinal flexors in physically inactive persons [12, 39]. This implies that the training programs should be also adjusted for disproportion in the strength and endurance of individual muscles stabilizing the spine. During inappropriately selected exercises, the function of weaker muscles is partially compensated by the stronger ones. In such cases, training results in progressive disproportion of exercised muscles, rather than producing expected beneficial effects.

*Passive rehabilitation*

Perhaps it is lack of unified recommendations regarding efficient and safe physical exercise, which promoted the so-called passive rehabilitation as a method to therapy back pain. Despite lack of reliable evidence for effectiveness of such activities, patients with back pain are routinely recommended to stay in bed, prescribed pharmacotherapy, stretching, massages and/or physical therapy [49]. All these activities may be perceived beneficial by the patients, as they often partially attenuate acute pain.

Individuals suffering from back pain frequently attribute their ailments to previous physical activity. Consequently, a person who experienced pain during movement is generally reluctant to physical training [60]. Therefore, physical exercise gains growing popularity as a method of rehabilitation in chronic pain, providing sustained improvement of motor function and enabling patients to return to work and to undertake the normal activities of daily living [8]. However, identification of muscles that require intervention, as well as directions and methods for rehabilitation are still problematic.

*Effects of physical exercise*

Many activities undertaken at home or at a workplace result in a considerable, sometimes health-threatening, spinal overload. The most burdensome are the activities that require the center of pressure to move forward, or are associated with forward flexion of the spinal joints or with the hip flexion, e.g. standing up from a supine position [51]. According to Liebenson [41], it is good coordination of the abdominal muscles, rather than the strength thereof, which may protect against back pain. However, although a number of risk factors for back pain have been identified thus far, these are weak muscles which are frequently considered a key cause of this pathology [26]. The most popular method for maintaining spinal performance is exercises improving strength of abdominal muscles [16]. Typically such exercises involve directly the rectus abdominis and external oblique muscle [14]. The popularity of these muscles as a training target results from the fact that their rehabilitation seems to be relatively easy.

For many years, popular exercises for abdominal muscles were the so-called sit-ups, i.e. simultaneous flexion of the hips and spine in a supine position [63]. However, still new exercises that would improve the strength and endurance of abdominal muscles, and simultaneously reduce the risk for back pain, were sought [18, 54].

Sit-ups are a common exercise for rehabilitation of abdominal muscles, although available evidence suggests that their consequences are not straightforward. Despite well-established risks inherent to this type of exercise, it is still popular as a measure of back pain control. The results of early EMG-based studies dealing with the abdominal muscle involvement during flexion of the spine and hips called into question beneficial effects of such exercises on spinal health [21, 47]. Since the results of research conducted 50 years ago were confirmed recently during well-designed studies involving state-of-the-art technologies, one should be skeptical about the usefulness of such exercises in the prevention and treatment of back pain [46]. Contraction of abdominal muscles, hip flexors and erector spinae during an initial phase of the trunk and hip flexion generate compressive forces affecting the vertebrae and intervertebral discs. Due to this overload, these movements are not suitable for either prevention or treatment of back pain [7]. All exercises starting in a

supine position with straight/knee-flexed legs and free/fixed feet, during which the subject elevates the trunk or lower extremities due to flexion of the hips, raise least controversies in the context of back pain. According to Johnson and Reid [30], compressive forces generated during the sit-ups can be reduced due to the knee and hip flexion. However, other authors stated that either extension or flexion of the knees during the sit-ups exert equally negative effects on the spine [1, 53]. Liebenson [41] observed that the sit-ups are associated with greater load of the vertebrae and intervertebral discs, especially when performed early in the morning when the muscle-spine system is relatively less stable [1].

Sit-ups with straight legs are generally assumed to be safer than the same exercise with knee- and hip-flexed legs. However, also this technique for the abdominal muscle rehabilitation may produce some adverse effects. Many previous studies documented incorrect patterns of muscle activation during the hip flexion in the course of sit-ups. Although such exercises involve the rectus abdominis, equally active are the hip flexors, typically over-contracted in contemporary humans with predominantly sedentary lifestyle. Not only this limits the extension of the hips, but more importantly, results in enhanced lumbar lordosis. Noticeably, a disproportion in the strength of the hip extensors and flexors is considered a principal risk factor for back pain [40].

Some authors recommend pure spine-flexion exercises, without hip flexion, to strengthen abdominal muscles [7, 11, 28, 34]. An EMG-based research confirmed empirically that mean activation amplitude for the rectus abdominis muscle during pure spine-flexion exercises is similar or greater than in the course of exercises involving simultaneous flexion of the spine and hips [36, 56]. This results in lesser involvement of the hip flexors, the strengthening of which is not recommended, without compromising the abdominal muscle activity. Due to lower risk, many therapists, coaches and athletes prefer the abdominal muscle-strengthening exercises during which flexion is limited solely to the spinal joints, whereas the hips and pelvis remain stable [17, 61]. However, such seemingly easy exercises are in fact demanding since they require high concentration from both the subject and therapist. Their effectiveness and elimination of side-effects depend on a degree to which the subject is able to flex the spine using solely the abdominal muscles, without activation of the hip flexors and posterior trunk muscles (erector spine, latissimus dorsi). The results of an EMG-based research imply that this task can be challenging for many subjects.

Although many authors claimed on the predominant role of "global" long muscles [32], a growing body of evidence from the last 10-15 years points to "local" short muscles as crucial for the stability of the spine [2]. However, according to Cholewicki and Van Vliet [15], none single muscle, either short or long [i.e. local or global] is not particularly important for the stability of the lumbar spine. Stabilizing role is played by both deep and superficial muscles, and therefore prevention and therapy of spinal disorders should not focus on any single anatomical entity [3, 9, 55]. Consequently, rehabilitation of trunk muscles should not be based on isolated exercises dedicated to a single muscle group. Also the exercises that strengthen abdominal muscles but simultaneously increase the risk for back pain, e.g. due to further strengthening of already over-toned muscles, are not recommended.

During recent decade, the so-called "core stability exercises" have been raising a growing interest as a method for spinal stability improvement [57]. "Core stability" is usually defined as one's ability to achieve and maintain control over the trunk, both at rest and during complex coordinated movements [42]. Transverse abdominal muscle, internal and external oblique muscles, rectus abdominis and multifidus muscle were identified as specific "core stability" muscles. Assuming that principal function of trunk muscles is stabilization of the spine, their rehabilitation should be aimed at achieving greater stability of this body part. The aim of core stability exercises, also referred to as general stability exercises, is to unload the spine, to enforce correct posture, to strengthen trunk muscles in order to provide adequate motor control of the whole body, and to improve one's body awareness. These assumptions were confirmed by the results of a meta-analysis conducted by Wang et al. [62], in which a 3-month regimen of core stability exercises turned out to be more effective than a general rehabilitation program. According to McGill et al. [43], each exercise can be considered stabilizing whenever it results in development of a motor pattern improving stability of the spine. Core stability exercises are as universal and safe for spinal performance that they can be practiced irrespective of age, both by beginning/elite athletes and older persons [48].

The first step in achieving stability of the spine should be appropriate activation of the internal oblique and transverse abdominal muscles. This can be achieved by the so-called abdominal hollowing, i.e. "drawing" the belly button to the spine. This technique is particularly recommended at early stages of the rehabilitation [13, 50].

A desired effect, i.e. appropriate tone of the target muscles, can be obtained if the individuals is able to draw the belly button kneeling with front support or half-crouching against the wall. The popularity of exercises based on abdominal hollowing has increased when Hodges and Richardson [29] showed that the activity of the transverse abdominal muscle during various movements is markedly greater in healthy persons than in individuals who suffer from back pain. Furthermore, the relative delay in the response of this muscle in individuals with back pain turned out to be the most evident of all examined muscles of the trunk and lower extremities. Consequently, the exercises during which principal movement is initiated by tensioning the transverse abdominal muscle are generally considered to be the most beneficial. Such movement requires a considerable involvement of the oblique muscles and transverse abdominal muscle, but only to a small extent involves the rectus abdominis [19, 37, 45]. However, one disadvantage of the exercises mentioned above stems from the fact that they focus on a single muscle. Obviously, this results in greater activity of the transverse abdominal muscle and simultaneous weakening of the internal and external oblique muscles, which in fact remain inactive during abdominal hollowing. A number of easier and more difficult variants of exercises involving abdominal hollowing [23, 55], adjusted for the capability of various groups of patients, have been described in literature. Nevertheless, O'Sullivan et al. [45] observed that some individuals may need up to 4-5 weeks to master abdominal hollowing, and Gibbons [22, 24] demonstrated that many persons with cognitive or sensorimotor deficits and poor general fitness cannot master this exercise at all.

Another, relatively new approach to simultaneous training of all abdominal muscles focuses on positioning the anterior chest wall [35]. During the exercises, the spine should remain in a neutral position (i.e. with the physiological anterior pelvic tilt) and anterior wall of the chest should be positioned parallel to the ground, with the sternum "reaching" out towards the belly button. Such position provides optimal conditions for work for the diaphragm and does not generate excess compressive forces affecting the lumbar spine.

A growing body of evidence points to the necessity of activating the whole girdle of muscles surrounding the spine, rather than focusing on a larger or smaller group of superficial or deep muscles. This hypothesis was supported by the results published by Sumiaki et al. [59]. The subjects participating in their experiment performed various exercises under an EMG control. Young healthy subjects performed five static exercises (abdominal bracing, abdominal hollowing, prone, side, and supine plank), as well as five dynamic exercises (V-sits, curl-ups, sit-ups, back extensions on the floor and on a bench). In conclusion, the authors stated that abdominal bracing is one of the most effective techniques for sustainable activation of deep and superficial abdominal muscles, being superior to dynamic exercises involving trunk flexion/extension movements [59]. The effectiveness of this method further increases whenever abdominal bracing is combined with limb or whole body movements [39].

Sumiaki et al. [59] demonstrated that maximal activation of the abdominal muscles without hollowing the lower abdomen, performed standing neutral-spine position with the feet shoulder-width apart (i.e. abdominal bracing) is one of the most effective techniques for rehabilitation of the internal oblique muscles, even compared to dynamic exercises involving trunk flexion/extension. Therefore, "abdominal bracing" should be included in the training programs aimed at improvement of the trunk and spinal stability [58]. Similar exercises dedicated to stabilization of the spine can be also used in the prevention and management of back pain. An interesting training program for spine stabilization, based on the abovementioned recommendations, was proposed by Arokoski et al. [4, 5]. The program includes 18 exercises performed standing, sitting, lying face up, face down, on either side and supported. The subject's task is to maintain stability of the spine, simultaneously making upper and lower extremity movements.

However, the outcome of exercise therapy aimed at improvement of spinal stability is not certain. Not every patient is ready for unassisted implementation of the proposed program. Arokoski et al. [6] observed that exercising at home did not result in a significant increase in strength and electric activity (EMG) of trunk extensors and flexors. Furthermore, Rossi et al. [52] showed that even an exercise supervised by a therapist may exert an unfavorable effect whenever inadequate strength of muscles on either side of the spine is compensated by stronger muscles of the other side. In such situation, an "apparently" correct movement (exercise) does not involve proportionally the muscles of either side, and as such exerts a negative effect. Despite extensive research on various methods and exercises aimed at strengthening of the muscles being crucial for spinal stability, still no universal solution has been identified.

## Conclusion

Despite extensive research on the influence of physical exercise on the occurrence of back pain in non-athletes and athletes, one can hardly identify the most accurate

and effective approach [57]. Exercise therapy can support the treatment but may also produce side effects if applied by a specialist having a strong sense of indisputability of his/her knowledge. Consequently, selection of an appropriate, individually adjusted program of training remains at the discretion of therapists and coaches.

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