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Original Article

Core strength training for patients with chronic low back pain

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Abstract. [Purpose] Through core strength training, patients with chronic low back pain can strengthen their deep trunk muscles. However, independent training remains challenging, despite the existence of numerous core strength training strategies. Currently, no standardized system has been established analyzing and comparing the results of core strength training and typical resistance training. Therefore, we conducted a systematic review of the results of previous studies to explore the effectiveness of various core strength training strategies for patients with chronic low back pain. [Methods] We searched for relevant studies using electronic databases. Subsequently, we evaluated their quality by analyzing the reported data. [Results] We compared four methods of evaluating core strength training: trunk balance, stabilization, segmental stabilization, and motor control exercises. According to the results of various scales and evaluation instruments, core strength training is more effective than typical resistance training for alleviating chronic low back pain. [Conclusion] All of the core strength training strategies examined in this study assist in the alleviation of chronic low back pain; however, we recommend focusing on training the deep trunk muscles to alleviate chronic low back pain.

Key words: Core strength training, Chronic low back pain, Resistance training

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INTRODUCTION

Chronic low back pain (CLBP) is defined as low back pain that persists for more than 12 weeks, and it is the most frequently reported clinical symptom of orthopedic diseases in Europe and the United States[1)]. More than 50% of people in the United States are affected by CLBP[2)], and it is the primary cause of work absence and permanent disability[3, 4)]. The core muscles, which are the primary muscle group for maintaining spinal stability[5)], can be divided into two groups according to their functions and attributes. The first group of muscles is composed of the deep core muscles, which are also called local stabilizing muscles. These muscles primarily include the transversus abdominis, lumbar multifidus, internal oblique muscle and quadratus lumborum[3, 6)]. The lumbar multifidus is directly connected to each lumbar vertebral segment[5)], and the transversus abdominis and lumbar multifidus activate a co-contraction mechanism. The abdominal draw-in that occurs during contraction provides spine segmental stability and maintains the spine within the neutral zone[7)]. In additional, these muscles provide precise motor control and are thus primarily responsible for spinal stability[6, 8)]. The second group of muscles comprises the shallow core muscles, which are also known as global stabilizing muscles, including the rectus abdominis, internal and external oblique muscles, erector spinae, quadratus lumborum, and hip muscle groups[9)]. These muscles are not directly attached to the spine, but connect the pelvis to the thoracic ribs or leg joints, thereby enabling additional spinal control. These muscles produce high torque to counterbalance external forces impacting the spine; thus, this group of muscles is secondarily responsible for maintaining spinal stability[6, 8, 10)]. When the core muscles function normally, they can maintain segmental stability, protect the spine, and reduce stress impacting the lumbar vertebrae and intervertebral discs[11)]; hence, the core muscles are also called "the natural brace" in humans[10)].

The causes of CLBP are complex, several of which are unknown[12)]. One major cause involves the weakening of the shallow trunk and abdominal muscles[12, 13)]. Mitigating CLBP and improving mobility typically involves strengthening these muscles[12)]. Another cause of CLBP is the weakening of or insufficient motor control of the deep trunk muscles, such as the lumbar multifidus and transversus abdominis[1)]. During physical activities, the trunk muscle tissues ensure the mobility and stability of the lumbopelvic region; thus, changes in trunk muscle activity (particularly in the lumbar multifidus and transversus abdominis) are typically observed in patients with low back pain[8)]. Core strength training is directed at training the deep trunk muscles[14)]. However,

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Table 1. Description and Jadad scores of reviewed articles

Authors	n	Description	Jadad scale
Akbari et al.[16]	49	Experimental group: motor control exercise Control group: general exercise	4
Andrusaitis et al.[17]	15	Experimental group: stabilization exercise Control group: strengthening of abdominal, back, and hip muscles	5
França et al.[18]	30	Experimental group: segmental stabilization exercises for strengthening the tranversus abdominis and lumbar multifidus Control group: superficial strengthening of the rectus abdominis, external and internal obliquus and erector spinae	4
Gatti et al.[19]	79	Experimental group: trunk balance exercises Control group: strengthening exercises of limbs and trunk	5

independent training is challenging for CLBP patients despite the existence of numerous core strength training strategies. Furthermore, no standardized system has been established for analyzing and comparing the results of core strength training and typical resistance training. Therefore, we systematically reviewed relevant studies to explore the effectiveness of various core strength training strategies at alleviating CLBP.

METHODS

The articles reviewed in this study were primarily obtained from the EBSCO and PubMed databases. The inclusion criteria were: studies published between 2008 and 2012 involving experimental research methods, CLBP patients, and core strength training strategies. Studies with non-English references and those that adopted departmental review or case report procedures were excluded from this study. Searches were conducted using key words such as CLBP, core strength training, trunk exercises, and trunk stability. Two sports medicine experts with at least 10 years of experience were invited to select the articles. The core strength training methods, sports treatments, evaluation methods, and study results of the reference studies were extracted and analyzed. Finally, the Jadad scale, which has a five-point scale (higher scores indicated higher-quality research), was used to rate the quality of the references[15].

RESULTS

After consulting with experts and reviewing the abstracts of 135 relevant articles, four articles were identified as suitable for this study. The four reviewed articles[16–19] yielded Jadad quality scores ranging between 4 and 5 (Table 1). In these studies, four core strength training exercises (i.e., trunk balance, stabilization, segmental stabilization, and motor control) were implemented for training the deep core muscles. Trunk balance exercises are aimed at enhancing subjects' balance by strengthening the trunk[19]. Stabilization emphasizes progressive core strength training techniques, such as supine, prone, sitting, quadruped, and standing stabilization exercises[17]. Segmental stabilization exercises focus on strengthening various deep core muscles[18]. Motor control exercises are based on motor control theory[16]. All of the control groups in the four reference studies performed typical resistance training to strengthen their trunk and lower limb muscles (e.g., curl-ups, straight-leg raises, and push-ups).

Table 2 shows the three types of evaluation method used in the four reference studies[16–19]. The first type was pain evaluation, which included the visual analog scale (VAS) and McGill pain questionnaire[16–19]. The second type was scale evaluation, for which the range minimum query (RMQ), Oswestry disability questionnaire (OSWDQ), and back performance scale (BPS) were used to evaluate the participants' disability levels[16–19]. The Short Form-12 (SF-12) was divided into physical and mental sections to evaluate the quality of life of CLBP patients[9]. The third type was an evaluation instrument involving a pressure biofeedback unit (PBU) and ultrasound[16, 18]. The four reference studies employed pre- and post-test evaluations to evaluate the effectiveness of the exercise interventions and experimental and control group comparisons[16–19]. According to the VAS and McGill pain questionnaire results of these studies, pain was reduced following core strength training, although no statistically significant differences were observed from the control groups. In contrast, the Roland-Morris questionnaire, SF-12, OSWDQ, PBU, and ultrasound muscle thickness measurements showed statistically significant improvements.

DISCUSSION

Four types of core strength training were identified in the four reviewed studies[16–19]. Trunk balance exercises encompassing the sitting, kneeling, quadruped, and supine postures involved alternating the supporting objects between hard and soft and instructing the participants to move their head or upper limbs with their eyes closed[16, 19]. Based on similar principles, stabilization, segmental stabilization, and motor control exercises were emphasized for retraining the motor control of the deep trunk muscles[16, 18]. Segmental stabilization exercises enhance spinal stability by focusing on the transversus abdominis and lumbar multifidus[18]. Motor control was employed to teach participants to contract their muscles (e.g., performing an abdominal draw-in maneuver while exhaling) while gradually increasing how long they could hold their breath by maintaining normal breathing for 10 seconds while performing 10 contractions. Subsequently, the participants performed dynamic exercises (e.g., the cat and camel positions)[16]. In the four reviewed studies,

Table 2. Intervention, assessment and results of reviewed articles

Authors	Intervention	Assessment	Results
Akbari et al.[16]	30 min/session, 2 sessions/week, 8 weeks, total 16 session	7.5 MHz B-mode transducer ultrasound, BPS, VAS	BPS and VAS decreased. Muscle thickness measurement of ultrasound increased.*
Andrusaitis et al.[17]	10 min bike warm-up; 40 min/session, 3 sessions/week, total 20 sessions	VAS, RMQ	VAS decreased. RMQ improved.*
França et al.[18]	30 min/session, 2 sessions/week, 6 weeks; 3 sets of 15 repetitions	VAS, McGill pain questionnaire, OSWDQ, PBU	VAS and McGill pain questionnaire decreased. OSWDQ and PBU improved.*
Gatti et al.[19]	15 min walking and 30 min flexibility (warm-up) exercises; 2 sessions/week, 60 min/session, 5 weeks, total 10 sessions	VAS, RMQ, SF-12	VAS decreased. RMQ and SF-12 improved.*

VAS: visual analogue scale; OSWDQ: Oswestry disability questionnaire; RMQ: range minimum query; PBU: stabilizer pressure biofeedback unit; BPS: back performance scale.
*$p < 0.05$, statistically significant difference between experimental group and control group.

the control groups performed typical resistance training using machines and free weights to train shallow muscle groups[16–19]. Compared with typical resistance training, core strength training is easier for CLBP patients to learn, although it is more challenging[19]. Additionally, no special equipment is required, and patients can independently practice core strength training at home, which is essential because home-based exercise programs can yield additional benefits for motivated patients. Furthermore, several studies have shown that typical resistance training can easily injure CLBP patients[16, 19].

Motor control plays a critical role in stabilizing the spinal system[20]. Maintaining lumbar spinal stability involves three interactive systems: the passive support system, which relies on the ligaments and fascias of skeletal muscles; the active contraction system, in which lumbar spinal movement and stability are maintained by contracting the core muscles; and the central nervous system, which plays a leading role in motor control[16]. The central nervous system can respond to sensations produced in the active and passive systems by using the central nerves to control motor coordination[20, 21]. The central nervous system governs physical actions, and prevents interference in order to maintain spinal stability and lumbar spinal movement[22].

Andrusaitis et al. reported a negative correlation between VAS and OSWDQ results, when a high pain level is associated with a high OSWDQ score[17]. The experimental group reported lower levels of pain after practicing stabilization exercises, although the reduction was not significant, compared with the control group, which performed typical resistance training. However, an analysis of the Roland-Morris questionnaire results revealed a statistically significant difference[17]. The similarity between these results and those reported by Gatti et al.[19] and França et al.[18] indicates that using disability evaluation instruments rather than pain evaluation instruments can clearly demonstrate the benefits of implementing core strength training over typical resistance training. In addition, Gatti et al.[19] and França et al.[18] reported that the Roland-Morris questionnaire, OSWDQ, and SF-12 results showed significant improvements in the experimental group compared with the control group. Evaluating subjects' disability level primarily involves analyzing their ability to perform functional (e.g., climbing stairs) and occupational activities[18, 19, 23]. Gatti et al.[19] asserted that disability scale levels are primarily evaluated based on functional activities that are a daily concern of CLBP patients. Thus, although core training and trunk balance exercises are challenging activities, they can reduce disability. Moreover, the effectiveness of such core training and trunk balance exercises is more easily perceived by patients than that of pain reduction methods[24]. França et al.[18] reported no difference in the VAS pain scores between experimental and control groups; however, significant improvement may have been undetectable because the pretest scores of both groups were low. Nevertheless, the reduction in pain indicates that the functional disability of the CLBP patients had improved markedly.

Objective evaluation instruments are necessary for determining the extent to which core strength training can alleviate CLBP. Using PBU and ultrasound, França et al.[16] and Akbari et al.[18] reported statistically significant differences between experimental and control groups. Using a PBU involves indirectly evaluating the movement of the transversus abdominis with a measuring instrument and an inflatable ball connected to a pressure guage. When filled with air, this simple device can be used to sense pressure change caused by bodily movements (specifically spinal movements), thereby facilitating the detection of transversus abdominis contractions[18]. For ultrasound evaluation, França et al.[16] used 7.5-MHz B-mode transducer ultrasonography to measure the thickness of the transversus abdominis and lumbar multifidus boundaries. Ultrasonography is more effective than pain scales at identifying statistical differences between the experimental and control groups[16, 18]. Thus, we recommend that future studies investigate the influence of core strength training on CLBP patients by adopting evaluation instruments that yield relatively more objective and discriminating results.

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