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Research Progress on the Application of Core Stability Training in Patients with Chronic Nonspecific Low Back Pain

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Abstract: *Core stability training plays a significant role in the rehabilitation process of patients with chronic nonspecific low back pain (CNLBP). To further explore the application progress of core stability training in CNLBP patients and provide rehabilitation references for clinical CNLBP, this study adopted the literature retrieval method to systematically sort out, summarize and conclude the application research of core stability training in the treatment of chronic nonspecific low back pain patients in recent years, and thus draw conclusions. The research found that in CNLBP patients, core stability training can effectively enhance the neuromuscular function of the abdomen and back, as well as the surface electromyographic signals of related core muscle groups. Suspension core stability training can effectively activate the core muscle groups of CNLBP patients, enhance the stability of the spine and the strength of the waist and abdomen, and achieve the effect of reducing the discomfort of the waist in CNLBP patients. Among the equipment core stability training, Swiss ball core stability training can effectively improve the daily living level of CNLBP patients, relieve pain, and long-term training can effectively reduce the recurrence rate, balance pad core stability training can significantly increase the strength of the waist, WBV core stability training can increase the strength of the core muscle groups of the waist in CNLBP patients and show good results in pain relief. Floor core stability training has a good effect in improving the pain, function, muscle strength, range of motion and flexibility of the waist. Among them, Pilates exercise maintains excellent short-term and long-term therapeutic effects, which can help reduce the recurrence risk of CNLBP and also improve the walking stability and quality of life of CNLBP patients.*

Keywords: *Core Stability Training, Chronic Nonspecific Low Back Pain, Chronic Low Back Pain*

1. Introduction

With the rapid development of modern society, people's living standards have been continuously improving, and their lifestyles have also changed accordingly, such as prolonged desk work, prolonged sitting with little movement, and lack of exercise, which have led to a significant increase in patients with low back pain. Low back pain is one of the most common chronic pain symptoms among adults. Internationally, low back pain is classified into non-specific low back pain (NSLBP) and specific low back pain (SLBP)[1]. Among them, NSLBP is more common, accounting for up to 85%. NSLBP refers to low back pain without a definite cause found through objective examination, and there are no definite changes in the histopathological structure. Clinically, low back pain with a course of ≥ 3 months and an undetermined cause is diagnosed as CNLBP.

The clinical manifestations of CNLBP are diverse, but the most common manifestation is pain, mainly concentrated in the lumbar region and the lumbosacral area. Most patients often experience such pain along with limited range of motion in the waist, decreased coordination of movements, stiffness in the waist, or weakened strength. For some patients with severe conditions, this pain sensation may even cause sleep disorders. This pain symptom usually gets relieved or disappears after bed rest, but it may worsen after bending over or sitting for a long time. During physical examination, localized tender points can be clearly felt, and the muscle tension in these areas often increases as well. Clinically, through conservative treatment methods such as massage, hot compress, and physical therapy, the pain symptoms of most patients can be temporarily relieved.

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Currently, there are many clinical intervention methods for CNLBP, but due to the complexity of the pathogenesis of CNLBP, there are no specific and targeted treatment methods at present, so the treatment effect cannot reach the expected ideal level. What's more, CNLBP has a high recurrence rate, which undoubtedly further increases the difficulty of clinical treatment and seriously affects the daily life of patients, and brings great life troubles to them. Core stability training occupies a crucial position in the exercise therapy for CNLBP. This training can effectively strengthen the abdominal and lumbar neuromuscular functions, significantly improve the condition of lumbar spine dysfunction, and can greatly alleviate the pain caused by daily life movements. Therefore, core stability training has a great help in improving the quality of life of CNLBP patients.

The study aims to explore the application progress of core stability training in patients with chronic non-specific low back pain (CNLBP), and to provide rehabilitation references for clinical treatment of CNLBP.

2. The Application of Core Stability Training in the Treatment of Chronic Non-specific Low Back Pain

Core stability is closely linked to unstable training. By using the training methods in an unstable state, the core stability of the body can be significantly improved. Unstable training refers to conducting exercise training under unstable environmental or conditions. During the training process, the body needs to constantly adjust its body posture and coordinate the neuromuscular functions to adapt to these frequent changes, thereby enhancing core stability. McGill S M[2] found that unstable training helps to improve and coordinate the core muscle groups, enhance the recruitment ability of neuromuscular systems, and core stability training on unstable surfaces can activate deep muscles in the waist, such as the latissimus dorsi, external oblique abdominis, and internal oblique abdominis. Currently, various exercise methods have been proven to be training methods for patients with CNLBP, including pelvic and hip joint training, water sports, and trunk muscle group strengthening training, etc[3]. However, among many training methods, core stability training is favored by patients with CNLBP. This core training not only has significant value for the recovery of proprioception after injury, but also can restore the functions of joints and muscles by activating muscle groups in the trunk or limbs [4-5] . In recent years, training methods such as suspended core stability training, equipment-based core stability training, and mat-based core stability training have emerged, providing more convenient and effective treatment methods for patients with CNLBP.

2.1 Suspension Core Stability Training

Suspension core stability training is fundamentally based on the basic principles of suspension. Through the core muscle groups of the human body controlling and strengthening their strength in an unstable state, this training enhances the neural-muscular coordination ability between the deep muscles of the trunk and various major muscle groups, thereby improving the body's control ability, stability, and balance during movement, and facilitating the attainment of rehabilitation goals [6].

Through this training method, it can increase the sensory input of the human body. During the training,one needs to constantly adjust their posture and movements to ensure the correctness of the actions, thereby maximizing the enhancement of neural-muscular control ability, activating the deep stabilizing muscles of the trunk, establishing the correct contraction pattern, and achieving the purpose of improving the discomfort symptoms of CNLBP patients. Yu Rui[7] selected 30 CNLBP patients for suspension core stability training, three times a week, for a total of 4 weeks. Before and after the treatment,the surface electromyographic signals of the affected side and the healthy side of the erector spinae and multifidus muscles during standing position lumbar flexion and extension were collected from the patients. The results showed that the surface electromyographic signals of the affected side were lower than those of the healthy side before training, and there was no significant difference in the surface electromyographic signals between the two sides after training. The study found that after using suspension for core stability training to treat CNLBP, the active movement ability of the affected side erector spinae and multifidus muscles was significantly enhanced, Mok NW[8] studied the effects of four different suspension core stability training methods on core muscles, namely, the plank hip abduction , chest press, 45° rowing, and hamstring flexion . It was found that the core muscle groups were activated to varying degrees. However, the activation degrees of the four methods were different. Among them, plank hip abduction activated the core muscle groups the most, and 45° rowing activated the core muscle groups the least.

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In conclusion, suspension core stability training can increase the surface electromyographic signals of the erector spinae and multifidus muscles. In addition, the plank hip abduction during the training can also efficiently activate the core muscle groups of CNLBP patients in the lumbar region, thereby increasing the stability of the spine and abdominal strength, etc., achieving the effect of alleviating the discomfort of CNLBP patients in the lumbar region, and is worthy of clinical recommendation.

2.2 Equipment-based core stability training

Equipment-based Core stability training refers to the method of conducting core stability training using various types of equipment. By establishing a less stable plane with different equipment for exercise training, during the training, ensure that the body continuously receives an unknown yet controllable external interference factor, to increase the activation degree of the core muscle group, thereby achieving the purpose of enhancing body stability. At the same time, through this plane for core stability training, the core muscle group can be activated to a greater extent [9]. In recent years, Swiss balls, balance pads, full-body vibration equipment, etc. are often used for core stability training.

2.2.1 Utilizing Swiss balls for core stability training

Guo Meitong[10] randomly divided 92 patients with NSLBP into a control group and a treatment group,with 46 patients in each group. The control group received massage and drug treatment, along with traditional lumbar and back muscle strength training. The treatment group received core stability training on a Swiss ball in addition to the massage and drug treatment. Both groups trained once a day, for a total of 8 weeks. After the experiment ended, patients were required to train themselves once or twice a week. The specific methods of core stability training for the treatment group were as follows:

(1) Double Bridge Exercise: The patient lies on their back, with both lower limbs placed on a Swiss ball. Each set lasts for 30 seconds, with 10 repetitions.

(2) Single-leg bridge exercise: In the movement pattern of the double-leg bridge exercise, lift the lower limb on one side. Each set should be maintained for 15 seconds, alternating between the left and right sides, for a total of 10 sets.

(3) Double-limb flexion bridge exercise: In the double bridge exercise pattern, the knee joints need to be flexed to move the Swiss ball towards the buttocks. Each set should be maintained for 15 seconds, for a total of 10 sets.

(4) Reverse bridge exercise: Place the Swiss ball directly beneath the torso, with both lower limbs on the ground, and the calves perpendicular to the ground. Maintain for 1 minute per set, for a total of 10 sets.

(5) Single-leg reverse bridge exercise: Start with the reverse bridge exercise and then lift one of the lower limbs. Maintain this position for 10 seconds. Alternate between the left and right sides and perform a total of 10 sets.

(6) Single-leg straight-leg reverse bridge exercise: Based on the reverse bridge exercise, extend the lower limb on one side, maintain for 10 seconds per set, alternate between left and right sides, for a total of 10 sets.

The results showed that after the treatment group completed 8 weeks of core stability training using Swiss balls, patients' pain and daily living ability had significantly improved compared to before the intervention. Moreover, the treatment effect was superior to that of the control group. During the re-examination after one year, it was found that the recurrence rate of NSLBP in the treatment group was lower than that in the control group. Based on this study, it can be concluded that conventional treatment combined with core stability training can effectively improve the therapeutic effect of NSLBP, and long-term adherence to training can effectively reduce its recurrence rate.

2.2.2 Core stability training with balance pads

Sung[11] selected a patient with spinal cord injury and conducted 12 weeks of core training on a balance pad. Before and after the intervention, they used a constant-speed muscle strength testing device to measure the peak data of the patient's lumbar flexion and extension. The specific method was as follows: before training, a foam roller was used for warm-up, and then 10 sit-ups and 15 bridge exercises were performed at the end of the balance pad, with a total of 4 sets. The results showed that after 12 weeks of core training on the balance pad, the patient's lumbar muscle strength significantly increased.

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2.2.3 Whole-body vibration-based core stability training

Whole body vibration (WBV) was first proposed by Nasarov in 1987 as a part of the daily strength training for gymnasts[12]. With the development of time, WBV technology has now been applied in rehabilitation, sports, and medicine. Yang Jie[13] selected 16 patients with chronic non-specific low back pain (CNLBP) and randomly divided them into the WBV group and the non-WBV group, with 8 patients in each group. The WBV group received additional whole body vibration stimulation on top of the regular exercise training, while the non-WBV group only underwent regular training. This study lasted for 8 weeks. Before and after the experiment, surface electromyography signals of the rectus abdominis and erector spinae muscles during lumbar flexion and extension were collected from the CNLBP patients in both groups. The study showed that the WBV device could increase the strength of the rectus abdominis and erector spinae muscles in CNLBP patients, thereby improving the functional support of the lumbar region in CNLBP patients. Xu Shanshan [14] selected 30 CNLBP patients and randomly divided them into the experimental group and the control group, with 15 patients in each group. The experimental group received WBV core stability training, 4 times a week, each training session lasting 5 minutes. The control group only received traditional core training. Both groups continued the training for 8 weeks. The results showed that WBV combined with core muscle strength training could significantly enhance the core stability of CNLBP patients and improve the stability during walking. Additionally, some scholars conducted literature searches using various databases and analyzed the effects of WBV on CNLBP patients in terms of pain and function [15] . Among the 7 published randomized controlled trials involving 418 CNLBP patients, 4 studies used pain as an indicator. The results showed that compared with the control group, WBV had a positive effect on pain. In the 6 studies measuring function, 3 high-quality studies indicated that WBV was beneficial. This scholar believes that WBV is beneficial for the recovery of CNLBP. However, due to the limited availability of WBV-related literature, it is still impossible to draw a conclusion that WBV is an effective intervention measure. Before providing clinical recommendations and supporting its use in CNLBP and exploring the best treatment plan, further research is needed.

In summary, using equipment for core stability training by CNLBP patients can effectively reduce their lumbar discomfort, enhance core muscle strength, and thereby improve the quality of life of CNLBP patients. Core stability training on Swiss balls is significantly superior to traditional rehabilitation training in reducing pain and recurrence rates. Core stability training on balance mats also has a significant effect in enhancing core muscle strength. However, due to the limited research data, there may be individual differences, and further research is needed. WBV can increase the strength of the rectus abdominis and erector spinae muscles in the lumbar region of CNLBP patients and enhance the stability of the core and walking. A few studies on the intervention of WBV on CNLBP patients' pain showed that WBV had a positive effect on pain. However, due to the limited number of WBV-related studies, the specific treatment methods and long-term intervention efficacy still need further research.

2.3 Core stability training on the mat

Core stability training on the mat is a training method targeting the core muscles of the waist. Its main purpose is to enhance the body's balance and stability both in static and dynamic states. This type of training is usually conducted on yoga mats or other soft surfaces, and it achieves the goal of strengthening the core muscles through various postures and movements, thereby improving the body's control over its center of gravity. Common forms of core stability training on the mat typically include the bridge pose and Pilates.

Yang Fangfang found that bridge exercises, as a common and effective exercise method, mainly reflect the endurance and strength of the deep muscle groups in the core area[16]. The research by foreign scholars Mannion also revealed that there is a close correlation between the endurance of the lumbar and back muscle groups and the stability of the core area as well as the incidence of pain[17]. Malki[18] further pointed out that the core area muscle endurance of patients with chronic low back pain often suffers from adverse effects. Therefore, improving the core endurance of patients is an important part in the exercise rehabilitation training.

Pilates training has been regarded as a kind of alternative and complementary exercise treatment method to medicine in recent years, and it holds an important position in exercise rehabilitation and general training. Pilates training is a method that emphasizes controlling the core muscle group, which can activate the core muscle group of patients, enhance the transmission power of the core muscle group to adjacent muscle groups, thereby optimizing the function of the movement chain and improving the accuracy and coordination of the whole body movement[19-20]. The Pilates exercises contain 7 factors

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related to CNLBP, namely breathing, posture, flexibility, movement control, strength, core stability, and mind-body connection. Among them, posture, movement control, and breathing are particularly important for improving the control force of the deep muscle groups in the trunk to alleviate the patient's low back pain [21].

Li Falin and Chen Shuang mainly analyzed Pilates in the field of fitness. They believed that after Pilates training, the proprioception of fitness practitioners improved, the stability of the core and the control ability of the body were enhanced, and at the same time, the elasticity and coordination control ability of the ligaments were also improved[22-23]. Liang Feng used clinical experimental methods to confirm that Pilates training can improve the balance function of the human body and enhance the cardiopulmonary endurance[24] . Song Cuicui and Weng Jiayin also analyzed the functional aspects of Pilates, and they believed that this training can improve the respiratory system ability of the human body, strengthen the spine of the human body and protect the lumbar vertebrae, and can improve the mental outlook and vitality of the human body[25-26]. Cherie Wells analyzed 14 randomized controlled trials and found that compared with conventional care and physical activity, Pilates exercise therapy for CNLBP has significant therapeutic advantages in terms of pain and function in the short term (4-15 weeks) [27] .Some studies conducted follow-up after the exercise intervention and found that the efficacy of Pilates exercise for CNLBP remained during the 12-month follow-up period, that is, Pilates exercise has excellent effects in short-term treatment and long-term efficacy maintenance, which is helpful to reduce the recurrence risk of CNLBP[28-29]. Wang Fei[30] selected 80 patients with CNLBP and randomly divided them into an observation group and a control group, with 40 people in each group. The observation group received conventional massage treatment combined with Pilates training, while the control group received conventional massage treatment. They tested the surface electromyogram of the erector spinae muscle before and after the intervention. After 4 weeks of intervention, the surface electromyogram of the observation group was significantly better than that of the control group. They believed that the improvement degree of symptoms in patients receiving conventional massage treatment combined with Pilates training was better than that in patients receiving only conventional massage treatment.

In conclusion, core stability training on the mat has a good effect in improving the pain, function, muscle strength, range of motion and flexibility of patients with CNLBP, which can effectively relieve the symptoms of CNLBP patients, reduce recurrence, and is a better method for preventing and treating CNLBP. Among the numerous literature on Pilates core stability training, most of them focus on the research and analysis of its therapeutic effects. However, there is no clear and unified standard for the training cycle and frequency of the related movements in Pilates core training. In the future, more in-depth research and discussion can be conducted on the detailed methods and approaches of Pilates for core stability training in patients with chronic non-specific low back pain.

3. Conclusions

Among patients with CNLBP, core stability training has shown high practicality and usage frequency. It can effectively enhance the neuromuscular functions of the abdomen and back, as well as the surface electromyographic signals of the related core muscle groups. Suspension core stability training can activate the core muscle groups of CNLBP patients, enhancing the stability of the spine and the strength of the waist and abdomen, and achieving the effect of alleviating the discomfort in the waist of CNLBP patients. In the case of equipment-based core stability training, the combination of Swiss balls and core stability training can effectively improve the daily living level of CNLBP patients, and long-term adherence to training can reduce the recurrence rate of CNLBP, Balance pad core stability training can significantly increase the strength of the waist of CNLBP patients, WBV core stability training shows significant efficacy in the short-term intervention. On the pad-based core stability training, it has good effects in improving pain, function, muscle strength, range of motion and flexibility of the waist. Among them, Pilates core stability training maintains excellent efficacy in both short-term and long-term treatments, can improve the walking stability of CNLBP patients, and can effectively relieve the symptoms of CNLBP patients and reduce recurrence.

At present, there are relatively few research papers related to the balance pad and WBV training included in the core stability training of the equipment. However, existing studies have indicated that short-term intervention for patients with CNLBP has obvious therapeutic effects, while the long-term intervention results and recurrence rates require further research. In the literature on core stability training on the pad, there is a lack of specific training methods and frequencies for patients with CNLBP. It is hoped that more outstanding scholars can conduct deeper research and discussions on the core stability training of patients with CNLBP using Pilates. Additionally, core stability training should involve the

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overall participation of the body and require the coordination of various body parts. However, most studies only focus on the waist and abdomen as the research subjects, which is not comprehensive enough. It is suggested that in future research, the sample size should be determined based on the principle of randomness, in line with larger clinical trials, in order to obtain more reliable evidence-based conclusions. At the same time, it is recommended that in the research related to core stability, the human body should be regarded as an interrelated whole rather than being studied only at the local level. This holistic perspective is conducive to a more comprehensive understanding of the roles played by different parts of the human body in maintaining core stability, and helps to design more comprehensive and effective training methods for core stability. Additionally, we should continue to focus on the research of the pathogenesis of CNLBP in order to better apply core stability training to the rehabilitation treatment of CNLBP.

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