REVIEWS

Application of core stability training in rehabilitation of motor function in children with cerebral palsy

Jiaojiao Zhao, Zhaohua Fu*

Department of Rehabilitation Medicine, Inner Mongolia Baogang Hospital, Baotou, China

Received: June 28, 2017 **Accepted:** August 21, 2017 **Online Published:** September 10, 2017
DOI: 10.14725/dcc.v4n3p26 **URL:** http://dx.doi.org/10.14725/dcc.v4n3p26

Abstract

Cerebral palsy is a syndrome caused by non-progressive brain injury and developmental defects from the start of conception until infancy. The main manifestations are dyskinesia and postural abnormalities in children. This article is to summarize the current application of core stability training in rehabilitation of children with cerebral palsy motor function, which aims to lay a foundation for clinical work and further related theoretical research.

Key Words: Cerebral palsy, Motor function, Core stability, Rehabilitation

Cerebral palsy is a syndrome caused by non-progressive brain injury and developmental defects from the start of conception until infancy. The main manifestations are dyskinesia and postural abnormalities in children.[1] How to effectively improve the motor function of children with cerebral palsy has been a hot issue in the field of cerebral palsy rehabilitation. In recent years, the core of stability training has been widely used in the field of rehabilitation medicine, such as nervous system rehabilitation, musculoskeletal system rehabilitation, sports injury rehabilitation and medical rehabilitation.[2] This article is to summarize the current application of core stability training in rehabilitation of children with cerebral palsy motor function, which aims to lay a foundation for clinical work and further related theoretical research.

1 The theoretical basis of the core stability

From the anatomy of human body, the core parts of the human body mainly refer to the spine, the hip and the lower extremities. Muscles mainly refer to the trunk and pelvis-related muscles, including 29 muscles attachment of lumbar-pelvic-hip (LPH), such as rectus abdominal muscle, obliquus externus abdominis, obliquus internus abdominis, musculus transversus abdominis, thoracolumbar fascia, quadratus lumborum, iliopsoas, gluteus maximus, gluteus medius, and erector spinae.[3] Core stability refers to the control of the pelvis and the body during exercise to stabilize the posture, to create a fulcrum for the upper and lower extremity movements, and coordination of upper and lower extremity force, so as to achieve the best results of the power generation, transmission and control.[4] The theoretical basis of the core stability comes from the theory of spine sub-system[5] proposed by Panjabi and the theory of "neutral zone".[6] Panjabi believes that the spinal stabilization system consists of passive sub-families, active sub-families and neuron-controlled sub-families. The passive sub-families include vertebrae, intervertebral discs and ligaments. The active sub-families mainly refer to the muscles and tendons surrounding the spine. The active sub-families

*Correspondence: Zhaohua Fu; E-mail: fuzhaohua66@163.com; Address: Department of Rehabilitation Medicine, Inner Mongolia Baogang Hospital, Baotou, China.

maintain spine stability under the control of the neuron control sub-families, while the passive sub-families contribute less to the core stability maintenance. When the body is in an upright position, there is an area between the vertebral spine that is free from passive spinal system activity. Neutral region, as an important clinical indicator, reflects the stability of the spine, and its scope changes with spinal injury or muscle weakness, and changes in the scope of the neutral zone are more sensitive than the changes of joint mobility in the relevant area.

2 Clinical application of core stability training in children with cerebral palsy

The motor ability of some children with cerebral palsy often shows a disproportion with limb muscle strength and muscle tension, which is mostly related to poor core stability. Therefore, it plays an important role in improving motor function of children with cerebral palsy.

2.1 Indications and contraindications

Core stability training, like other rehabilitation therapies, has its own strict indications and contraindications. Related studies have pointed out that children with cerebral palsy are candidates for core stability training if they satisfy the following conditions: (1) Diagnostic criteria for cerebral palsy developed by the 9^{th} Chinese Children's Cerebral Palsy Rehabilitation Academic Conference in 2006;[7] (2) A certain cognitive ability to understand, follow the instructions and cooperate with the training.[8] (3) Children or guardians have informed consent to the rehabilitation training method.[7] Some scholars also require the age of children with cerebral palsy should be controlled between 9 months to 5 years.[9] The limitation may be related to the cognitive ability of children, concentration of attention, endurance and so on, and the relationship needs further confirmation. Some patients are not suitable for the training if they meet the following conditions: (1) patients with obvious joint deformation or deformity;[9] (2) suffering from severe epilepsy and mental illness, etc.;[8] (3) heart, lung, liver, kidney and other important organs dysfunction.[10] During the rehabilitation treatment of cerebral palsy, clinicians and therapists should strictly adhere to the above indications and contraindications so as to achieve satisfactory results on the premise of ensuring the safety of cerebral palsy children and not wasting medical resources.

2.2 Training methods

Common core stability training types include stable ground resistance training, unstable suspension training and on-ball training. Instability training is to provide patients with an unstable support surface. The stable muscle of the layer is actively involved in balanced and coordinated movements, thus effectively improving the strength and stability of the core muscle group;[4] such as suspension training, pilates training and Swiss ball training, are all unstable training methods based on the principle of core stability training.[11–14] In the stability training of children, the type of core stability training must be compatible with the developmental stages of children and follow the principle from static to dynamic, from simple to complex.[8] Specifically, it is the gradual transition from posture maintenance, balance maintenance and other static training to dynamic training using a balance board, balance disk, Swiss ball or roller and so on, and finally to dynamic lower body exercise training.[15] When children with cerebral palsy can not complete the training tasks independently, the therapist assists them in maintaining the trigger posture, and helps the children to complete the training with the maximum effort through instruction, then gradually reduces the auxiliary until the children can complete the training action independently.

2.3 Training intensity

There is currently no uniform standard of core stability training intensity. Most scholars advocate the core stability training as a parallel training program with other exercise therapy timed separately, and the training time is 30-50 min/time, 1 time/day, 3-5 times/week.[9,16] While some scholars advocate taking part of the time from the exercise therapy training for core stability training, the training duration is generally shorter. It is recommended that 15 min is appropriate.[17] The whole course of core stability training is generally consistent with other sports therapy training courses, which usually takes 3 months. According to the analysis of the current research results, the core stability training of the above two kinds of intensities has an effect on improving the core stability of children with cerebral palsy. However, it is still to be further explored whether the two are better or not.

2.4 Efficacy evaluation method

The core stability is closely related to the core muscle strength of the body. The core muscle strength is a concrete manifestation of core stability. Therefore, measuring the core muscle strength indirectly reflects the core stability of the body. At present, the measurement methods for the muscular strength of the core muscle mainly include the surface electromyography[18,19] and various exercise tests, the exercise tests include the flat support[20] and torso activities in all directions,[21] etc.

As a means of rehabilitation intervention, the result of the core stability training can be obtained by evaluating the improvement of the function of the patient's motor function. At present, the research tools used to assess the effect of core stability training in children with cerebral palsy are generally the same, mainly using gross motor function measure (GMFM),[22] which probably due to the direct and close relationship between the gross motor function and the body's core stability. In the application of GMFM scale assessment process, the researchers mainly select the different functional areas to evaluate the different purpose of the study. If a study is conducted to observe the effect of core stability training on sitting position ability, we should focus on selecting the A area related to sitting ability and representing the turning ability and evaluating the B area which represents the sitting ability.[23] Other scholars especially use special balance ability test tools when evaluating the effect of core stability training, such as the Biodex Blance System of USA and Berg Balance Scale.[24] There are also some studies which include other relevant measures besides GMFM. For example, Jin BX et al. introduce the level of sitting scale (LSS) for assessing the impact of core stability training on sitting ability of children with cerebral palsy.[25] When observing the effect of core stability training on fine motor function and activities of daily living in children with spastic cerebral palsy, some researchers use Peabody fine motor development test and functional independence test to evaluate the curative effect.[26] Generally speaking, the tools for evaluating core stability training efficacy are united and diverse. To a certain extent, it reflects the relative maturity of core stability training in rehabilitation intervention for children with cerebral palsy, and ensures the objective unity and comprehensiveness of evaluation results.

2.5 Efficacy evaluation

Relevant studies have confirmed that rehabilitation effect of the core stability training for children with cerebral palsy is positive. It was found that after 12 weeks of training, the centroid envelope area of the children in the core stability training group was significantly smaller than that in the control group without the core stability training in Chen TC et al.'s report[10] by observing the influence of core stability training on the balance function of children with cerebral palsy. The trajectory length of the center of gravity along the x-axis and y-axis in the eyes with or without eyes closed was significantly smaller than that of the control without core stability training, indicating that core stability training can promote the improvement of balance function in children with cerebral palsy. Another study found that the GMFM-88 scale of children with cerebral palsy in the core stability training group was significantly better than that in the control group.[26,27]

3 Mechanism of core stability training in children with cerebral palsy

The active sub-family in the human spinal subfractions plays a crucial role in the maintenance of core stability. It mainly maintains the core stability through the following mechanisms: Firstly, intra-abdominal pressure resulted from the internal oblique, external oblique, transverse abdominal muscles, diaphragm, pelvic floor muscles and thoracolumbar fascia make the abdominal cavity full of pressure to fight the vertebral physiological lumbar vertebra, limit lumbar vertebral segmental movement in order to achieve the purpose of maintaining spinal stability. Increased intra-abdominal pressure may also reduce the pressure load between the spines, thereby reducing the risk of injury at the same time. Secondly, when the trunk is rotated, the antagonist muscles of the obliquus externus abdominis and obliquus internus abdominis contract simultaneously, which has a stable effect on the lumbar spine. When the human torso is not affected by the external load, the hip and trunk muscles are inactivated, at which point the passive subline contributes more to the maintenance of core stability.[28] However, when the diaphragm strength is insufficient, the extensor movement of the spine will be compensated, which will destroy the intra-abdominal pressure regulating system and the spinal stabilization system, resulting in an increase of the compressive load of the spine and a decrease of the core stability.[29–31]

The dyskinesia and postural abnormalities in children with cerebral palsy mainly reflect in the movement of extremities, but this abnormality is not simply corrected by functional training of the extremities. In children with cerebral palsy, the control ability of trunk and pelvis is weakened, which directly restricts the coordination ability of children's movement and balance.[2] The abnormal respiratory muscle tension makes the intra-abdominal pressure severely affected, and further destroys the core stability. Core stability training provides a near-end stability for distal limb movements, achieves a proximal-to-distal force pattern, and creates a torque that moves and protects the distal joint.[31] The core stability training enables the nervous system to continue to receive the proprioception signals from the vestibule, the visual center, the muscles, the tendons and the ligaments. The body balance can be regulated by activating and controlling muscles that maintain body stability. This training method can enhance the deep muscle recruitment and excitability of the body, and improve the coordination, sensitivity and balance ability of muscles.[32] In the course of improving head control ability, core stability training can improve the neck and back muscles of children with cerebral palsy, enhance muscle strength, improve the symmetry of spine and body axis maneuvering ability, so as to achieve the ability. In the process of improving sitting ability, core stability training can improve strength and muscle tone of lumbar abs, hip muscles and lower limb muscles,

eliminate abnormal posture of lower extremities, and obtain seats dynamic balance, thereby improving sitting ability. In short, the core of stability training is to enhance the ability of physical center to control limbs and make up for the lack of stability in individual body training, thus speeding up the rehabilitation process and improving the rehabilitation effect.

4 Conclusions

At present, the core stability training has been gradually applied to the rehabilitation of children with cerebral palsy. It has been basically reached agreement in indications, contraindications, training principles, methods and curative effect evaluation, and the effect is affirmative. However, there are also some problems at the same time. The first is the aspect of training intensity. Time is counted separately or partly from exercise training without affecting the original exercise training time, and the use of former is more than that of the latter. Although they both have a positive curative effect, the difference between them is not yet clear. The second is the aspect of the efficacy evaluation. The majority of studies are using the GMFM scale, by observing changes in gross motor function to indirectly assess the improvement of the core stability of children. If there is a special core stability evaluation, we can directly determine whether motor dysfunction and degree of impairment are related to core stability so as to provide a clear guidance for rehabilitation of children with cerebral palsy.

In summary, the core stability training is an effective treatment for the rehabilitation of children with cerebral palsy. It is worth to promote and apply in the rehabilitation of cerebral palsy, but cooperation from more departments is needed to standardize treatment programs, improve the relevant theory, lay the foundation for the guidance of clinical treatment and related research work.

Conflicts of Interest Disclosure

The authors have no conflicts of interest related to this article.

References

[1] Chinese Association of Rehabilitation Medicine-Specialized Committee of Children's rehabilitation, China Association of Rehabilitation of Disabled Persons-Specialized Committee of Cerebral Palsy Rehabilitation in Children. The definition, classification and diagnostic conditions of cerebral palsy. Chin J Phys Med Rehabil. 2007; 29(5): 309.

[2] Ma BX. Zhang JK. The theory of "core stability" and the rehabilitation of cerebral palsy. Chin J Rehabil Med. 2012; 27(12): 1183-1186.

[3] Chen XP, Li YM. Training of the core stability force. Chinese Sport Science. 2007; 27(9): 16.

[4] Panjabi MM. The stabilizing system of spine. Part 1. Function, dysfunction, adaptation, and enhancement. J Spinal Disord. 1992; 5(4): 383-389. PMid: 1490034. https://doi.org/10.1097/00002517-199212000-00001

[5] Niu BZ. Application of core stability training in the field of rehabilitation medicine. The Journal of Medical Theory and Practice. 2015; 28(10): 1300-1301, 1304.

[6] Panjabi M. The stabilizing system of the spine. Part II. Neutral zone and instability hypothesis. J Spinal Disord. 1992; 5(4): 390-397. PMid: 1490035. https://doi.org/10.1097/00002517-199212000-00002

[7] Xu JL, Zhao YZ, Wang G, et al. The effect of core stability training on the recovery of gross motor function in children with involuntary cerebral palsy. Chin J Phys Med Rehabil. 2015; 37(3): 199-200.

[8] Xie QY, Hou M, Zhao JH, et al. The effect of core stability training on motor function in children with spastic cerebral palsy. Chin J Rehabil Med. 2014; 29(6): 528-532.

[9] Liu QX, Wan ZC. The effect of core stability training on the gross exercise of children with cerebral palsy. Journal of Ezhou University. 2013; 20(5): 70-71.

[10] Chen TC, Jiang DJ, Ye YW, et al. The effect of core stability training on balance function in children with cerebral palsy. Chin J Phys Med Rehabil. 2012; 34(7): 524-525.

[11] Klinc JB, Krauss JR, Maher SF, et al. Core strength training using a combination of home exercises and a dynamic sling system for the management of low back pain in pre-professional ballet dancers: a case sedes. J Dance Med Sci. 2013; 17(1): 24-33. https://doi.org/10.12678/1089-313X.17.1.24

[12] Jennifer F, Esther F, Margaret G, et al. Pilates based core stability training in ambulant individuals with multiple sclerosis: protocol for a multi-centre randomized controlled trial. BMC Neurol. 2012; 12(1): 19. PMid: 22480437. https://doi.org/10.1186/1471-2377-12-19

[13] Kim SG, Yong MS, Na SS. The effect of trunk stabilization exercises with a swiss ball on core muscle activation in the elderly. J Phys Ther Sci. 2014; 26(9): 1473-1474. PMid: 25276039. https://doi.org/10.1589/jpts.26.1473

[14] Behm DG, Drink EJ, Willardson JM, et al. The use of instability to train the core musculature. Appl Physiol Nutr Metab. 2010; 35(1): 91-108. PMid: 20130672. https://doi.org/10.1139/H09-127

[15] Yu H, Xu GX. The effect of core stability training on motor function in children with cerebral palsy. Chinese Journal of Rehabilitation. 2014; 29(4): 309-310.

[16] Song X, Lin XM, Zhou LX. Acupuncture combined with core stability training for treatment of cerebral palsy. Chinese Journal of Rehabilitation Theory and Practice. 2011; 17(1): 68-69.

[17] Wang YF, Li XJ, LV Y, et al. The effect of core stability training on the gross motor function and walking ability of children with spastic cerebral palsy. Chinese Journal of Rehabilitation Theory and Practice. 2012; 18(4): 350-353.

[18] Rogan S, Riesen J, Taeymans J. Core muscle chains activation during core exercises determined by EMG - a systematic review. Praxis. 2014; 103(21): 1263-1270. PMid: 25305118. https://doi.org/10.1024/1661-8157/a001803

[19] Hibbs AE, Thompson KG, French DN, et al. Peak and average rectified EMG measures: which method of data reduction should be used for assessing core training exercises. J Electromyogr Kinesiol. 2011; 21(1): 102-111. PMid: 20655245. https://doi.org/10.1016/j.jelekin.2010.06.001

[20] Tong TK, Wu S, Nie J. Sport-specific endurance plank test for evaluation of global core muscle function. Phys Ther Sport. 2014; 15(1): 58-63. PMid: 23850461. https://doi.org/10.1016/j.ptsp.2013.03.003

[21] Okada T, Huxel KC, Nesser TW. Relationship between core stability, functional movement and performance. J Strength Cond Res.

2011; 25(1): 252-261. PMid: 20179652. https://doi.org/10.1519/JSC.0b013e3181b22b3e

[22] Shi DW, Xu JJ, Zhang YF. The application of core strength training in the treatment of cerebral palsy. Chin Mod Doctor. 2013; 51(30): 128-129.

[23] Zhang WY, Zhang HX, Zhu YF, et al. Clinical study on the effect of core stability training on the sitting ability of cerebral palsy. J Pedia Tradit Chin Med. 2012; 8(6): 34-36.

[24] Li D, Liu JJ, Liu YQ, et al. Effect of core stability training on functional recovery of children with cerebral palsy. Chinese Journal of Rehabilitation Theory and Practice. 2015; 21(5): 583-585.

[25] Jin BX, Zhao Y, Li SY, et al. The effect of core stability training on the sitting ability of children with cerebral palsy. Chin Pediatr Integr Tradit Western Med. 2014; 6(4): 324-325.

[26] Guo YL, Li XJ, Sun QF, et al. The effect of core stability training on fine motor function and daily living activity in children with spastic cerebral palsy. Chin Pediatr Integr Tradit Western Med. 2014(5): 434-436.

[27] Song X, Lin XM, Zhou LX, et al. The clinical study of the effect of core stability training on the walking ability of cerebral palsy. J Med Res. 2011; 40(10): 120-122.

[28] Li L, Walhelm A. The history and present situation of the research on the core stability. Sport Science Research. 2011; 32(5): 1-9.

[29] Frank C, Kobesova A, Kolar P.Dynamic neuromuscular stabilization & sports rehabilitation. Int J Sports Phys Ther. 2013; 8(1): 62-73. PMid:23439921.

[30] Kibler WB, Press J, Sciascia A. The role of core stability in athletic function. Sports Med. 2006; 36(3): 189-198. PMid: 16526831. https://doi.org/10.2165/00007256-200636030-00001

[31] Ben KW, Sciascia A. Kinetic chain contributions to elbow function and dysfunction in sports. Clin Sports Med. 2004; 23(4): 545-552. PMid: 15474221. https://doi.org/10.1016/j.csm.2004.04.010

[32] Fredericson M, Moore T. Muscular balance, core stability, and injury prevention for middle-and long-distance ruanners. Phys Med Rehabil Clin N Am. 2005; 16(1): 669-689. PMid: 16005399. https://doi.org/10.1016/j.pmr.2005.03.001