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Trunk Stabilization and Its Rehabilitative Effects in Children with Cerebral Palsy

Serebral Palsili Çocuklarda Gövde Stabilizasyonu ve Rehabilitatif Etkileri

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Abstract

The trunk has a major role in providing dynamic stabilization in postural reactions. It also plays a critical role in supporting upper and lower extremity movements, loading, and protecting the spine. Trunk stabilization is the maintenance of trunk postural control and movement despite the disturbing effects of gravity, internal and external perturbations.

Cerebral palsy (CP) is a non-progressive neurodevelopmental disease. Weak trunk control is common among children with CP. Trunk stability is important in rehabilitation because of its contribution to the child’s activity and participation. However, the results of trunk stabilization training in CP rehabilitation are limited, and few studies have emphasized the importance of trunk stabilization in CP.

Considering the growing interest in supportive and novel rehabilitation methods in children with CP, this paper aimed to (i) describe the main features of neck and trunk stabilization (ii) summarize the possible therapeutic effects of neck and trunk stabilization methods based on different approaches in patients with CP. As a result, the literature demonstrates that these exercises benefit the rehabilitation process in reducing the negative effects of trunk instability. Increasing trunk stabilization with different techniques can improve the child’s upper-lower extremity skills, visual-perceptual functions and balance abilities.

Keywords: Neck Stabilization, Trunk Stabilization, Exercise, Cerebral Palsy

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Öz

Postüral reaksiyonlarda dinamik stabilizasyonun sağlanmasında gövdenin rolü büyüktür. Ayrıca üst ve alt ekstremite hareketlerini destekleme, yüklenme ve omurganın korunmasında kritik önemi vardır. Gövde stabilizasyonu, yerçekimi, iç ve dış pertürbasyonların olumsuz etkilerine rağmen gövde postüral kontrol ve hareketin sürdürülmesidir.

Serebral palsi (SP), ilerleyici olmayan nörogelişimsel bir hastalıktır. Zayıf gövde kontrolü, SP'li çocuklar arasında yaygındır. Çocuğun aktivitesi ve katılımına olan katkısı nedeniyle gövde stabilitesi rehabilitasyonda önemlidir. Bununla birlikte, SP rehabilitasyonunda gövde stabilizasyon eğitiminin sonuçları sınırlı olup SP'de gövde stabilizasyonunun önemine vurgu yapan çok az sayıda araştırma yapılmıştır.

SP'li çocuklarda destekleyici ve yeni rehabilitasyon yöntemlerine artan ilgiyi göz önünde bulundurarak, bu makale (i) boyun ve gövde stabilizasyonunun temel özelliklerini tanımlamayı (ii) SP'li hastalarda farklı yaklaşımlara dayalı boyun ve gövde stabilizasyon yöntemlerinin olası terapötik etkilerinin özetini vermeyi amaçlamıştır. Sonuç olarak literatür, gövde instabilitesinin olumsuz etkilerini azaltmada bu egzersizlerin rehabilitasyon sürecine yarar sağladığını göstermektedir. Farklı tekniklerle gövde stabilizasyonunun arttırılması çocuğun üst-alt ekstremite becerilerini, görsel-algısal fonksiyonlarını ve denge yeteneklerini geliştirebilir.

Anahtar Kelimeler: Boyun ve Gövde Stabilizasyonu, Egzersiz, Serebral Palsi

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Introduction

Cerebral palsy (CP) is a non-progressive neurodevelopmental disease. Weak muscles and amyotrophy cause muscle imbalance. Unfortunately, inadequate trunk control is quite high among children with CP. Basic trunk movements are essential for maintaining mobility and postural adjustments during extremity movements. The trunk has an impact on motor movements, and it has an interdependent interaction with various bodily components and nerve tissues. Trunk stabilization is the ability to control the movement and posture of the trunk on the pelvis and legs in a way that allows for extremity movements and provides optimum force generation, transfer and control despite gravity, internal and external perturbations (1). It is also required to control trunk movement during routine activities such as standing, sitting, and walking. Dexterity of arm and hand functions may decrasing in stabilization insufficiency (2).

Trunk control is a part of postural control, and it is active even in the first months of life (3). Postural control problems, including trunk control, are one of the key points for motor dysfunction in children with CP. Stability of trunk posture is considered important in children with CP because it leads to the child's activity and participation restrictions. Unfortunately, these children have got marked impairments, both in static and dynamic aspects of trunk control (4). They have difficulty maintaining the right posture, balance and holding or collecting objects. Trunk stability is one of the focal points in supportive and new rehabilitation approaches because of its contribution to the child's functionality and independence (5).

The effects of trunk stabilization training and its importance for successful CP rehabilitation have been started to investigate mostly in recent years. In this paper, we aimed to define the primary characteristics of trunk stabilization and to summarize the possible therapeutic effects of the neck and trunk stabilization methods based on different approaches.

Methods

Researches, reporting that trunk stabilization exercise, is effective in increasing muscle activity in children with CP have entered the literature since 2009. The PEDro, PubMed, Science Direct databases were scanned within the scope of this review. "Trunk stabilization", "neck stabilization", neck – trunk stabilization exercise" and "Cerebral palsy" search terms were used for literature research. The inclusion criteria for this review were as follows a) clinically diagnosed CP; b) studies published between January 1, 2009, and 31 December 2020; c) studies written in Turkish or English; d) studies included the search terms in the sections of title and summary; e) researches that are thesis, original article and case series. Review studies, letters to the editor, abstracts, conference proceedings, and studies with adults were excluded. A total of 440 studies were found after the initial search. When screening the titles and abstracts sections, 388 studies were excluded, and 12 studies were removed because of duplication. A total of 30 studies were analysed in this review; 26 of them were original articles, 3 of them were accepted thesis and only one was a case series study.

Trunk Stabilization And The Postural Control

The postural control system is made up of three parts: support, stability, and balance. The interaction of the head, trunk, arms, and legs is also essential to keep the body upright against gravity. To ensure synchronization between head and limb motions, as well as the muscles of the neck, information from the body and surroundings is concurrently conveyed to the neck and trunk. During postural control, the functions of the head and neck modify the body's base against the surroundings and provide a solid foundation for the visual and vestibular systems (6). The muscles that manage the head and neck regions have secure attachment sites in the trunk. In addition, the latissimus dorsi, pectoralis major, hamstrings, quadriceps and iliopsoas muscles, which are the primary movement muscles for the distal segments, attach to the center of the pelvis and spine. The upper and lower trapezius, hip rotators and gluteal muscles, which are the major stabilizer muscles for the extremities, also attach to the trunk (1, 7). With these features, the trunk is the foundation for distal body mobility, which includes neck mobility (8).

Trunk stability, postural control, and balance function are all dependent on head control. As the development of the vertebral extensor continues from head to toe the erector muscle with the antigravity effect begins to strengthen (9). On the other hand, babies can raise their chin and head in the supine position at about 6th month. These activities necessitate trunk stability. This situation explains why children with CP, who have unstable trunk muscles, cannot complete these movements adequately. The development of muscle strength is hampered by a delay in the acquisition of neck orthotopic response. This delay reduces the activity of the neck muscles that support the head, as well as the head’s stability. In the end, leading to a loss of head control. This situation impairs the person’s ability to maintain their center of gravity and deteriorates orienting responses and balance reactions, resulting in major balance issues (10).

The lumbar spine is segmentally stabilized by the transversus abdominis and multifidus muscles, whereas the rectus abdominis generates torque. In the light of this information, the erector spinae are superficial trunk muscles (11). Trunk stabilization exercises are generally used for the treatment and prevention of problems originating from the lumbar region. These exercises, help to increase the activation of the superficial trunk muscles as well as the deep trunk muscles. The intervention exercises that used, according to Okubo et al., delivered not only high levels of deep trunk muscular activity but also co-activation of deep and superficial trunk muscles (12). Beneck et al. demonstrated that trunk stabilization exercises accompanied by lumbar lordosis increases lumbar multifidus muscle activation, provide deep multifidus force generation and a compressive boot that increases intervertebral stability. As a result, Beneck et al. methods contribute to the reduction of the load on painful passive structures of the spine (13).

Lack of trunk muscle control leads to impairment in postural control and stabilization of the trunk. Stabilization of the trunk is necessary for the extremities to maintain efficient load transfer, coordination of distal and proximal movements, and the regulation of force or energy during integrated kinetic chain activities (14). Trunk-stabilizing muscles also help to maintain spine and pelvic stability. These muscles, generate and transfer strength from large to small regions of the body during extremity movements. These muscles’ central placement is ideal for managing the proximal stability required for specific distal segment movements. It is a crucial link in the kinematic sequence of shoulder abduction in the upper limb, particularly the thoracic spine (15). Trunk stabilization enhances the interaction between strength and stability by activation of multiple spinal segments for force generation, and proximal stability during extremity movement, shoulder and scapular movement (1). On the other hand, biomechanical studies, show the relationship between trunk muscle strength and knee alignment in the frontal plane during single-leg squat movement (16). Knee abduction moment is positively linked with lateral trunk lean (17). Furthermore, deep trunk muscles are known to be the first to activate when the major movement in the lower extremities is activated (18). According to these researches, the dynamic line-up of the lower limbs during dynamic tasks is affected by poor motor control and weak trunk muscles. As a result, lower extremity function can be affected by trunk muscle dysfunction and lack of stability, which increases the risk of lower extremity injury.

The core muscles are crucial for maintaining stability while moving the extremities. To increase core stability, several physiotherapists have performed strengthening exercises such as trunk stabilization exercises. Studies are reporting that trunk stabilization exercises are effective in increasing muscle activity (19). According to Konin et al., the transverse abdominis muscle was the most important one of core muscles during movements, and the external oblique muscle was the primary component in maintaining stability by fixation of the pelvis (20). Moreside and McGill suggested that a significant improvement in hip range of motion can be achieved with core endurance exercises, and proximal stiffness may affect distal mobility. Because trunk muscular function contributes to hip and thigh muscular activity, as well as lower extremity activities, strengthening trunk function is essential in the prevention and therapy of lower extremity injuries (21).

Because Since almost all kinetic chains contribute to core strength and balance, trunk stabilization is necessary to properly use kinetic chains connected with upper and lower extremity function. When the trunk is stable, the upper and lower extremities can be used properly, and the upper and lower extremities also assist to adjust for any trunk instability that may present. In addition to functional hand movements such as sitting, playing in sitting positions and eating, trunk stability plays a major role in the maintenance of activity and participation function in activities of daily living, such as sitting in a wheelchair. The insufficiency of the trunk muscles causes axioskeletal misalignment, and postural instability during limb movement, resulting in an undesirable substitute movement model (22, 23).

Trunk stabilization exercises contribute to muscle activation and stabilization by training the abdominal and anterior thoracic cage muscles. Thus, with the support of the anterior trunk muscles, the sacroiliac joint (SIJ) is effectively locked. For example, the transversus abdominis can be contracted to effectively minimize SIJ laxity and offer "corset-like" stability (24-26). Stabilization exercises provide immediate gains in postural control and trunk stability. In addition, trunk stabilization exercises have been reported to immediately enhance postural control while standing quietly with eyes closed (27). Therefore, improving balance due to stabilization exercises may contribute to reducing the incidence of an ankle sprain.

The thoracolumbar fascia connects the upper and lower extremities through the gluteus maximus and latissimus dorsi. This fascia surrounds deep group muscles of the trunk, provides 3-dimensional support to the lumbar spine, helps core stabilization. The thoracolumbar fascia is believed to activate proprioception. In this context, synergistic muscles can also provide inhibitor and facilitator inputs to agonist muscle groups to maintain balance (1, 28).

The Effects of Trunk Stabilization Training in Children with CP

Trunk stability and movement of the extremities are closely related to normal developmental processes. Failure to improve trunk stability in neurodevelopmental pathologies such as CP also negatively affects motor development. Weakness of trunk muscles, increased upper and lower extremity muscle tone, loss or delay of postural reflex, and loss of ability to move the upper and lower extremities flexibly lead to trunk instability in children with CP (29). Trunk muscle tone is typically reduced, especially in tetraparesis and diparesis patients. In addition, treatment response is worse in cases such as tetraplegia with poor head control. These children show abnormal pelvic retroversion in the sitting position, bending the body forward and shrinking their shoulders to complete the defective posture. In the shrinking position, this results in a larger limitation of arm function and severely limited upper limb function for everyday living or learning activities. A novel study showed that individual trunk training is a useful method to increase activation of trunk extensors. The authors also reported that this training method can be used safely without the risk of increasing muscle tone of upper and lower extremities in children with CP (30). Children with spastic CP have difficulty holding or collecting objects due to insufficient proximal stability and may drop objects immediately after handling (31-32). This can be explained by the close relationship of the limb muscles with the trunk stabilization muscles during movement (33).

Children with CP who have insufficient head and trunk stability have difficulty maintaining the right posture and balance. Weak muscle strength and amyotrophy cause muscle imbalance in these children. In addition, children with CP make wrong decisions about the strength, speed and direction needed to maintain posture and balance. These causes limited movement control as well as deficits in visual-perceptual function and visual-motor ability (34). It is known that head, trunk stability and postural control is also associated with the visual-perceptual function (35, 36). Therefore, added extra proprioceptive stimulation connected to the position and movement of the spinal joints in rehabilitation programs may make the trunk-stabilizing muscles' functions easier.

Enhancing Upper Extremity Functions with Stabilization Exercises in CP

Children with CP need the ability to maintain posture and trunk stability to perform hand movements during play and eating. This ability requires trunk stabilization and adequate trunk muscle strength. Akbas and Gunel have shown that individually structured trunk training could be used for improving trunk, upper and lower extremity motor functions and activity levels of children with bilateral spastic CP (37).

Jeong reported that upper extremity performance improved with trunk stabilization exercises in a study he conducted on children with spastic CP (38). He stated that increasing neck and trunk stabilization improved upper extremity and visual-perceptual function (39). Indeed, cervical muscle endurance plays an important role in supporting the head weight in head movements and maintaining the balance of the head-thoracic vertebra (40). Improving neck and trunk stabilization can provide a complementary effect on the neck-trunk complex upper limb function in children with CP.

Effects of Neck Stabilization Exercises in Rehabilitation of CP

Trunk stabilization exercises have positive impacts on neck muscle strength, as the increases in neck muscle strength are associated with trunk stabilization. Furthermore, because the neck and trunk are complementary, it is appropriate to combine neck and trunk stabilization exercises in order to develop static and dynamic balance capacity. Firstly, cervical flexion exercise will activate the lower abdominal muscles. Secondly, activating the erector muscles of the neck, and the upper thoracic vertebrae through the extension, forcing the neck back into the supine position.

Lastly, bridge exercise positions will activate deep abdominal muscles. Activation of these muscles helps the subjects to feel the pelvis' posterior inclined motion. Improving trunk control in sitting position by neck flexion exercises and bridge exercises in children with CP supports these results (41).

Improving Balance in Children with CP

It is also important to develop balance in children with CP within the scope of rehabilitation programs. Many neurological and biomechanical elements, including the visual, vestibular, and somatosensory systems, collaborate with each other to maintain balance. Compound exercises that take the link between trunk and neck into account can improve the ability to maintain balance. At this point neck and trunk stabilization exercises are the foundation of static and dynamic balance abilities (42). Trunk stabilization exercises can also have an immediate therapeutic effect on balance. According to Kaji et al., trunk stabilization exercises immediately improved static and dynamic balance in the prevention of lower extremity injuries, as assessed with the subjects performing quiet standing with eyes closed on a platform (27). Additionally, Ari et al. showed that adding trunk exercise inside to the conventional physiotherapy programs of children with CP, also affects balance, trunk extensor strength and motor function positively (43).

Cranio-Cervical Flexion based Trunk Stabilization Exercises in children with CP

Chung et al. has investigated the effect of trunk stabilization exercise based on cranio-cervical flexion on gross motor performance and postural alignment change in children with spastic CP. Participants, who were randomly divided into two groups, have applied one of the 8-week cranio-cervical flexion-based trunk stabilization exercise or trunk stabilization exercises. At the end of the research, it was stated that cranio-cervical flexion-based trunk stabilization exercise improves gross motor function and postural alignment in children with spastic CP and can be utilized alongside traditional physical therapy (44).

Effect of Neck and Trunk Stabilization On Feeding Function in Children with CP

The feeding functions are also affected in children with CP in addition to other problems (45). Adequate head, neck, and trunk control are to be also important to achieve serial and coordinated oral motor movements, crucial for the stability, control, and coordination of oral structures during the feeding/swallowing process (46). Control and mobility of the oral structures for feeding and swallowing, are linked to head - trunk control and stability. Low postural tone and poor proximal neck and trunk stability cause slower and longer eating, resulting in lower food intake (47). Gisel et al results had proved interaction between oral structures and postural control of the "whole body." Novel studies were focused to determine the controls of such a relationship (48).

Serel Arslan et al. showed that the severity of chewing difficulties increased as trunk postural control diminished. Their research found that 76.3% of children with spastic CP had chewing issue and that the severity of this condition was connected to the amount of gross motor function and trunk postural control. They suggested that postural control training may be added to a chewing training program to ensure adequate chin and lip closure, as well as to facilitate tongue movement for more effective, safe chewing by providing proper head and trunk control (49). Limited study in literature reported that Combined physiotherapy programs, including neck alignment exercise may increase masticatory muscles motor control (50). Furthermore, stabilization of the neck and trunk, forward neck flexion, or supported recline positions can be used to promote more effective eating behaviours (46).

Sling Stabilization Exercises in Rehabilitation of CP

Sling exercise stands out as an effective practice in trunk stabilization training. After sling-based trunk stability exercise programs in children with CP, who can walk independently, not only balance but also weight transfer and shift have been improved. Sling-based trunk stability exercise activates deep muscles through sensory-motor training required to maintain joint stability, thereby increasing motor maturity. Sling-based trunk stability exercise on an unstable surface can increase functional recovery, stability and stimulate neurologically proprioceptive sensory input (51). Yeom found that children with spastic diplegic CP between the ages of 10 ~ 14 show a positive effect on static and dynamic foot pressure after the trunk stabilization training, which includes a 6-week sling exercise program (52).

Trunk stabilization with sling also has an important effect on gross motor function. This method improves the stability of the proximal region and the ability to sustain the righting reaction and protective extension reaction of the extremities. In addition, the contraction of agonists and antagonists together facilitates joint stability and proprioceptive sensation and improves gross motor function. Motor maturity can also be significantly improved, especially in the sitting, and standing posture (53).

Hippotherapy for Trunk Training in Children with CP

Strengthening the trunk with hippotherapy and horse riding provides positive therapeutic effects in improving trunk stability, balance, walking speed, stride length, and pelvic kinematics (average pelvic anterior tilt, pelvic anterior tilt at initial contact, pelvic anterior tilt at terminal stance) in infants with CP. Hippotherapy has also provided successful results in motor activity, especially in children with spastic diparesis and infantile CP who move independently (54-56).

Swiss Ball Exercises in Rehabilitation of CP

The Swiss ball is an effective and adaptive equipment that improves postural control, trunk rotation, pelvic femoral rotation, trunk balance-lateral weight shifting. A Swiss ball exercise is a posture-correcting rehabilitation tool as well as treating and preventing neck and waist discomfort. It can be used to improve perceptual balancing abilities as well as muscle strength, endurance, flexibility, and coordination. Exercises that are performed on uneven surfaces, such as the Swiss ball, can create more activity and are useful in reducing musculoskeletal harm by increasing dynamic balance, strengthening the core muscles of the trunk, and maintaining stability in upright positions (57, 58).

Conclusions

This review has highlighted the evidence for trunk stabilization in the rehabilitation of patients with CP. Increasing trunk stabilization has a significant effect on a child' upper-lower extremities, neck and visuo-perceptual function, participation and balance, feeding, chewing and swallowing abilities. Improving trunk stability of children with CP, the studies on the enhancement of the trunk by hippotherapy, horseback riding, Swiss ball exercise and neck-trunk stabilization exercises that has been added to children's specific rehabilitation protocol, have verified the beneficial effects of these therapeutic approaches. In physiotherapy sessions, these exercises seem useful to reduce the negative effects of trunk instability on the rehabilitation process. We think that interventions for trunk instability in CP should be planned holistically, especially trunk stabilization exercises should be included in the intervention plan.

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