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DEVELOPMENT OF LOW POSTURAL TONE COMPENSATORY PATTERNS – PREDICTED DYSFUNCTION PATTERNS IN LOWER PART OF THE BODY

ROZWÓJ WZORCÓW KOMPENSCACJI OBNIZONEGO NAPIĘCIA POSTURALNEGO U DZIECI – PRZEWIDYWANE WZORCE DYSFUNKCJI W DOLNEJ CZĘŚCI CIAŁA

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Abstract
Lower postural tone is not always associated with central nervous system structural damage. There is such kind of tone that stays within the broadly defined normal range, but is characterized by distinct decrease of tone of the deep muscles responsible for stabilization. External syndromes are features of active or passive compensation observed in the postural and motor patterns. Active compensation of the lower muscle tone is associated with excessive use of the superficial muscles for stabilization that leads to limitation of motion in the joints and to functional shortening of some muscles. Active compensation mechanisms in the lower part of the body cause decreased anterior pelvic tilt, functional shortening of the hamstring muscles and pes cavus (spastoidal type). Passive compensation is initiated in case of decreased tone of both deep and superficial muscles. Stabilization is kept with considerable participation of the spatial shape of bones, ligaments, meniscus and passive properties of the muscles. Tendency to hypermobility of the periarthritis elements is observed, which is manifested by increase of the physiological range of motion in the joints. As a result in the lower part of the body postural faults develop, which are characterized by increased lumbar lordosis, anterior pelvic tilt, valgus knee and feet (atetoidal type). Observations indicate that lower tone of the muscles responsible for stabilization triggers off the sequence of compensatory mechanisms that ultimately lead to specific postural faults.

Key words: postural tone, body stabilization, low postural tone, compensatory mechanism, posture faults

Streszczenie
Stan obniżonego napięcia posturalnego nie zawsze związany jest z uszkodzeniem struktur ośrodkowego układu nerwowego. Można wskazać taki rodzaj napięcia, który zawarty jest w obszarze szeroko pojętej normy, ale wyraźnie cechuje się obniżonym napięciem głębokich mięśni odpowiedzialnych za stabilizację. Zewnętrznym objawem są cechy kompensacji czynnej lub biernej obserwowane we wzorach posturalnych i motorycznych. Kompensacja czynna obniżonego napięcia wiąże się z nadmiernym wykorzystaniem do stabilizacji mięśni powierzchownych, co doprowadza do zmniejszenia zakresu ruchomości w stawach oraz do funkcjonalnego skrócenia niektórych mięśni. Mechanizmy kompensacji czynnej w dolnej części ciała

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SPECIFICITY OF THE PELVIS AND LOWER LIMBS CONTROL IN CHILDREN WITH SPASTOIDAL TYPE

Setting about to analyze the quality of the lumbar segment and pelvic control, it is worth examining this issue from the angle of Snijders and Vleeming studies (1-3). The authors describe self-locking mechanism of the sacroiliac joints in participation of both active (force closure mechanism) and passive subsystem (form closure mechanism) (4-6).

The force closure of the sacroiliac joints is being accomplished through activation of the global myofascial-ligamentous systems generating forces perpendicular to the joint surface and hence increasing compression and friction force. The muscles responsible for accomplishment of the force closure create a few characteristic trains (longitudinal posterior train, oblique posterior and anterior train, lateral train). Activation of these trains to a variable extent can influence sacrotuberous ligament tension causing excessive or too low compression of the sacroiliac joints (1, 2, 7, 8). Whereas the form closure mechanism is being accomplished by the proper spatial orientation of the joint surfaces and wedged shape of the sacrum. The latter “rams” between the pelvic bones on the pattern of so-called keystone in the architectural arc (1-3).

It seems that in children with low postural tone cooperation of these mechanisms in stabilization is disturbed. Depending on the type of tone, excessive use of the force closure or form structure mechanism is observed.

In children with spastoidal type excessive activation of the global myofascial complexes generating compressive forces to the joint surface are observed. This has direct impact on the pelvis and lower limbs alignment. Hip muscle adductors increased activity constitutes the reason for lower limbs alignment in the pattern of extension, adduction and internal rotation (fig. 1a, b). In this situation, the femur heads to a lower degree undergo the pressure to the acetabulum. As a consequence, the acetabulum steepness and valgus femur necks may be diagnosed in later years. Increase of the force closure participation limits the ability of postural component involvement through the impact on the hip joints surfaces spatial orientation.

Analyzing the issue of excessive use of the force closure mechanism it is particularly worth noting the role of the hamstrings, which are included in the posterior longitudinal train. Van Wingerden J.P. and co-authors describe the mentioned muscles as for both internal and external stabilization of the sacroiliac joint (9, 10). Internally this influence is associated with strong anatomical and physiological relations between the biceps femoris muscle and sacrotuberous ligament. In the ontogenetic development, such movement activities are observed which are associated with preparation of the discussed muscles for future functions. The hamstrings of the newborn infant demonstrate shortening due to the flexed fetus position, and just five months old infant is able to grab its feet by its hands with knee joints extended (fig. 2a).

Children with spastoidal type on account of considerable hypertonia of the lower limbs muscles omit the discussed ability which prevents from gaining the full length of the hamstrings (fig. 2b). It is difficult to state unambiguously whether the stiffness of the hamstrings frequently observed in adults is associated with the lack of formation of the full length of these muscles in ontogenesis or whether it is acquired as a result of the compensatory mechanisms involvement in later years. Nevertheless, increased tension of these muscles in adults may be
Fig. 1. Excessive activation of the global myofascial complexes in infant with spastoidal type: a) in prone position – strong activation of posterior longitudinal train; b) in standing position – strong activation of anterior oblique train.

Ryc. 1. Nadmierna aktywacja dużych zespołów mięśniowych u niemowląt z typem spastoidalnym: a) w pozycji pronaowej – silna aktywacja taśmy podłużnej tylnej; b) w pozycji stojącej – silna aktywacja taśmy ukośnej przedniej.

Fig. 2. Diversity of the hamstrings activities in infants of similar developmental age: a) ability to extend the knee joint during feet grab in infant with normotonic type; b) lack of the knee joint extension during feet grab in infant with spastoidal type.

Ryc. 2. Zróżnicowanie aktywności mięśni kułszowo goleniowych u niemowląt w podobnym okresie rozwojowym: a) zdolność wyprostu stawu kolanowego podczas chwytymania za stopy u niemowlęcia z typem normotonicznym; b) brak wyprostu stawu kolanowego podczas chwytymania za stopy u niemowlęcia z typem spastoidalnym.

part of the involuntary arthrokinematic body defense mechanism that has the task of reducing the spinal load (11-13). If such situation lasts long enough, the hamstrings (especially biceps femoris) become shorter and secondarily cause dysfunction of the sacroiliac joint and lumbar segment (9). Tensed and shorten hamstrings effectively limit anterior pelvic tilt, which can be observed from the infancy (fig. 3a, b).

The alignment of the muscle trains that provide the most economic stabilization in the lumbar segment shows some diversity within this group. Observations indicate two possibilities: decrease of lumbar lordosis (fig. 4a) or its shortening with distinct deepening (short and deep lordosis) (fig. 4b).

However, reduction of lumbar lordosis occurs the most often, which is automatically connected with reduced anterior pelvic tilt.

Shortening of the hamstrings has direct effect on the muscles, which constitute their functional continuation, that is, on gastrocnemius muscles. The heads of these muscles through the adhesion to the upper parts of the femora condyles reach up and
surround the hamstrings tendons. The latter descend, surround the gastrocnemius muscle and adhere to the tibia and fibula bones. The sole part of the foot constitutes the last link of the functional connections of the muscles placed on the posterior surface of the lower limb and specifically plantar fascia, tendons and venters of the short fingers flexors muscles (14). It can be expected that formation of the foot would be the result of the functions of the muscles placed above. It can be conjecture that in children with spastoidal type, development of the pes cavus occurs as a result of the strong tension of the muscles of the lower limb posterior part.

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Insufficiency of the active subsystem observed in children with atetoidal type imposes the obligation to take over the stabilization function by the passive subsystem. Interpretation of this issue in the aspect of Vleeming and Snijders studies, allows to conclude that distinct reduction of the force closure participation imposes increase of the form structure participation in the stabilization of the lumbar segment (1-3).

By reason of the reduced tone of both local and global muscles in children with atetoidal type normal activation of global myofascial complexes producing perpendicular compressive forces to the joint surfaces are not observed (fig. 5, 6a, b).

Insufficiency of the active subsystem already in infants affects the pelvis alignment in the substantial anterior tilt in both supine and prone positions (fig. 7a, b).

After obtaining the upright posture this condition become even more visible and maintenance of the spinal axis falls primarily on the passive subsystem structures (fig. 8). Resulting system resembles lower crossed syndrome type described by Janda with considerable anterior pelvic tilt and weak stabilization of the hip joints (15). It is necessary to emphasize that in the form closure mechanism maintenance of the stability does not require energy input, because it is accomplished as a result of the proper spatial orientation of the joint surfaces as well as the wedged shape of the sacrum. It is also worth paying attention to the hyperextension of the knee joints, which are used as the additional form of the stabilization in the passive compensatory mechanism (fig. 8).

Such compensatory mechanism leads to insufficiency of the medius and minimus gluteus muscles that can result in excessive internal rotation of the hip joint in

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**Fig. 3.** Decreased anterior tilt of the pelvis observed in the infant with spastoidal type: a) in supine position; b) in prone position.

**Ryc. 3.** Zmniejszone przodopochylenie miednicy obserwowane u niemowlęcia w typie spastoidalnym: a) w pozycji supinacyjnej; b) w pozycji procyjnej.

**Fig. 4.** Variants of the pelvic alignment in spastoidal type: a) decreased lumbar lordosis; b) deepened and shortened lumbar lordosis.

**Ryc. 4.** Warianty ustawienia miednicy w typie spastoidalnym: a) zmniejszona lordoza lędźwiowa; b) pogłębiona i skrócona lordoza lędźwiowa.
Furthermore, it is worth paying attention to relation between the passive compensation mechanisms with occurrence of the scoliosis. Increased anterior pelvic tilt observed in the children with atetoidal type favors self-bolting of the sacroiliac joints. Spatial projection of the facet joints in the lumbar segment cause their bolting in the maximal spinal extension. A situation, in which joint surfaces of the two neighbor segments are in the optimal contact cause abolishment of any additional degrees of freedom of movement. In other words, all lumbar segment is bolted in extension. The direct consequence of lumbar lordosis lengthening is neutralization of the thoracic kyphosis and development of the hollow back in the sagittal plane (Fig. 8). Here is that many of the contemporary authors observe flattening of the thoracic kyphosis in subjects with idiopathic scoliosis (22, 23). Sommerville as early as in 1952 had stated the appearance of decreased thoracic kyphosis in course of the thoracic scoliosis (24). A dozen years later Roaf had revealed that in the idiopathic scoliosis anterior spinal column (including the upright posture (fig. 9) (16). Such situation increases compensatory forces in the lateral compartment of the femoroibial and femoropatellar articulation joints, whereas shift of the body weight on the medial side of the foot results in the longitudinal medial arch flattening and pes planus as well as valgus ankle (17–21). vertebral bodies and intervertebral discs) is longer than posterior spinal column (25). Longitudinal studies carried out within 3 years on the group of 896 children show that subjects with scoliosis angle’s value > 10° acc. to Cobb were taller and had reduced thoracic kyphosis in comparison with children without any
deformations of the spine (26). Tomaszewski also indicates the essential role of the thoracic kyphosis flattening as well as multi-segmental limitation of the antireflexion in this spinal segment in the pathogenesis of idiopathic scoliosis (23).

If we take into consideration the fact that in the thoracic segment vertebral bodies transfer vertical load primary, then in case of thoracic kyphosis flattening this force to the higher degree become transferred through the facet joints.

What is worse based on the mathematic scheme of the spine it has been revealed that some of the spinal segments inclined posteriorly generate dorsally directed shear forces (27). Spatial projection of the facet joints in the thoracic segment predisposes them to performance of the movement particularly in the crosswise section, thereby not ensures full rotational control of the vertebrae, especially in the situation of dorsally directed shear forces (28, 29). Studies of Castelein and Veraart show that posterior inclination of the vertebrae in the sagittal plane constitutes prediction of the progressive idiopathic scoliosis (30).

Therefore, in case of the thoracic kyphosis flattening shear forces are transferred through the facet joints
then at their significant freedom in crosswise plane little additional internal or external impeding variable is sufficient to throw the segment off its peculiar balance and to cause its gradual rotation to the one side. Because, as it is known, there is always a link between the rotational movements of the spinal segment and the lateral flexion movements, favorable situation occurs to initiate the lateral scoliosis.

Considering the above, it can be stated that the primary source of many idiopathic scoliosis may be the passive compensatory mechanism, which leads to thoracic kyphosis flattening. Confirmation of these hypothetic deliberations could be retrospective examination of the children with diagnosed postural hypotonia and cyclic screening of the children with the atetoidal type.

Perhaps, detection of the passive compensation in infancy would allow to record early symptoms of lateral scoliosis that would be crucial for further treatment.

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