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DEVELOPMENT OF LOW POSTURAL TONE COMPENSATORY PATTERNS IN CHILDREN – THEORETICAL BASIS

ROZWÓJ WZORCÓW KOMPENSACJI OBNIŻONEGO NAPIĘCIA POSTURALNEGO U DZIECI – PODSTAWY TEORETYCZNE

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Abstract

Neurological literature indicates the existence of children with low postural tone without association with central nervous system damage. This fact induces to think about mechanisms, which allow these children to maintain upright posture. There is a suspicion that compensatory mechanism included in this process, enables to achieve upright posture, but at expense of body posture quality. Observations of children's developmental stages caused determination of some postural tone area, which comprise both children with normotonia and with low postural tone without characteristics of central nervous system (CNS) damage. Set of specific qualities allows determination of two types of low postural tone: spastoidal and atetoidal type.

Spastoidal type is characterized by deep trunk muscles (local) low postural tone compensated by excessive tension of superficial muscles (global).

Atetoidal type includes children with low postural tone in both deep and superficial muscles. At inefficient active subsystem, verticalization proceeds at excessive use of passive subsystem qualities, that is meniscus, ligament, bone shape, and muscles passive features.

From neurodevelopmental point of view compensatory mechanisms can be used in children with low postural tone in order to achieve upright posture, but at expense of body posture quality.

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

Streszczenie

W literaturze neurologicznej sugeruje się możliwość występowania obniżonego napięcia posturalnego, także w stanach nie związanych z uszkodzeniem ośrodkowego układu nerwowego (OUN). Fakt ten skłania do zastanowienia się nad mechanizmami, które umożliwiają tej grupie dzieci, uzyskać i utrzymać pozycję pionową. Z dużym prawdopodobieństwem można założyć, że proces ten oparty jest na mecha-nizmie kompensacyjnym. Z jednej strony pozwala on osiągnąć cel, z drugiej jednak zaburza jakość postawy. Obserwacje rozwoju dzieci spowodowały wytyczenie pewnego obszaru napięcia, w którym mieszczą się zarówno dzieci z normotonią, jak też dzieci z obniżonym napięciem bez cech uszkodzenia OUN. Zbiór specyficznych cech pozwolił na określenie dwóch typów obniżonego napięcia posturalnego: typ spastoidalny oraz atetoidalny.

Typ spastoidalny cechuje się obniżonym napięciem głębokich mięśni tułowia (lokalnych), które kompensowane jest poprzez nadmierne napięcie mięśni powierzchownych (globalnych).

Typ atetoidalny charakteryzuje się obniżonym napięciem, zarówno w mięśniach głębokich jak i powierzchownych. Wobec powyższego przy niewydolnym podsystemie czynnym pionizacja przebiega

przy nadmiernym wykorzystaniu właściwości podsystemu biernego – łąkotki, więzadła, kształt kości, pasywne właściwości mięśni.
Z neurorozwojowego punktu widzenia mechanizmy kompensacyjne służą dzieciom z obniżonym napięciem posturalnym do uzyskania pozycji pionowej, ale kosztem jakości ukształtowania postawy ciała.

Słowa kluczowe: napięcie posturalne, stabilizacja ciała, obniżone napięcie posturalne, mechanizm kompensacji, wady postawy

DEV. PERIOD MED., 2014, XVIII, 3, 374-379

INTRODUCTION

Normal motor activity observed in children with normotonia allows appropriate preparation of the subsystems, which are responsible for stabilization of the body in the upright posture. Achievement of the harmony in scope of the mentioned muscle systems is manifested by normal body posture formation. It can be assumed that children with low postural tone, having no possibilities of accomplishment of the complete movement patterns repertory, can not achieve normal body stabilization. In development of children with low postural tone series of atypical postural patterns are observed. They can be called the mechanisms, which compensate postural tone deficit.

Compensation issue constitutes the object of the numerous studies. It appears, for instance, in the studies of Lieber who claims that adaptive answers in the locomotor system concern compensation of the given muscle function by involving other muscles to the given activity as well as distinct change of the range of motion in order to reduce overload of damaged muscle (1-4). Furthermore, Lewit believes, that our bodies may compensate until adaptive abilities will be exhausted and then decompensation occurs, and symptoms become noticeable in the form of the contractures, limitations of the mobility, pain (5). Liebenson reaches a conclusion that some muscles demonstrate tendency to hypertonia and contractures, whereas their functional antagonists tend to hypotonia and weakness (6).

The authors in a different ways prove that most of dysfunctions of the locomotor system occur as a result of adaptive processes, as a body or its part tries to compensate the immediate or gradual requirements of daily activities. However, no theory indicates the cause of the discussed phenomenon.

It can be only conjecture that low postural tone is the primary problem, and compensation used for the optimal body stabilization constitutes the secondary one.

The aim of the study is then to draw attention to the potential factors causing dysfunction patterns of the locomotor system in children with mildly reduced postural tone. Observation that fluid connection between infancy and subsequent developmental stages does not exist, induced the authors to undertake the present study. Low postural tone in the head-trunk axis is diagnosed in infancy, yet after a few years, the primary diagnosis is not being continued in the same children, and observed abnormalities are defined as posture faults (lumbar hyperlordosis, valgus knee or feet).

Insightful interpretation of these issues will enable the physiotherapist to carry out accurate diagnosis as well as effective and full of comprehension management process.

DETERMINATION OF LOW POSTURAL TONE TYPES AND STRATEGY OF COMPENSATION

It is extremely difficult to define standards of normal postural tone and all the more to determine its deviations. Postural tone is determined by very few authors, among whom Shumway-Cook and Woolacott can be listed, who define the mentioned term as the increased activity level in the antigravitational muscles which help to maintain the body upright against the force of gravity (7-11). Definition of the postural tone has been also proposed J.M Howle: postural tone is the distribution of the tone in the muscle groups which act together to adopt and maintain specific posture (12).

Taking into consideration the neurodevelopmental concept as well as contemporary reports on the body stabilization, the authors propose their own interpretation of the discussed term in the present study. Normal postural tone according to authors' means centrally conditioned integrated activity of the local and global muscle groups that provide body stabilization in the static and dynamic conditions expressed by normal postural alignment and normalized tone of the peripheral body parts (13). On account of that, abnormal postural tone should be interpreted analogically as a disturbed cooperation of the deep and superficial muscle groups, which in consequence triggers off the need for compensation (13).

Postural tone may reach diverse values depending on the quality of CNS functions from normotonia through mild (paratonia) and moderate (hypotonia) disturbances up to severe disorders (atonia). In the present study the area of postural tone mildly deviated from standard (paratonia) has been submitted for analysis.

It is also essential to emphasize the fact that the individual body parts require to a variable extent

participation of the locomotor system structures for stabilization. Broadening to all the body the model of the lower segment stabilization drawn up by Panjabi, it can be discerned that three subsystems decide about the upright posture maintenance: neural control, active and passive (14, 15).

Myers points out additionally that the structures which maintain the spine in the individual segments are diversified in respect of the participation of the mentioned subsystems (16). Stabilization of the thoracic segment is maintained by sternocostal complex, kyphosis sacrococcygea by the pelvic bones and pelvic ligaments, and heel by the shape of foot bones. Cervical and lumbar segments are more dependant on muscle balance, because muscles create these curvatures and maintain their shape.

For this reason, stabilization and formation of the cervical and lumbar lordosis, which constitute movable parts of the spine, to a higher degree depend on the surrounding myofascial structure (16) (fig. 1).

Such is the participation of the individual structures in maintenance of the upright posture in normal conditions, whereas in case of children with low postural tone this system undergoes disturbances. Excessive use of the active or passive subsystem structures then occurs. However, within the active subsystem great functional diversity of the muscles exists. Bergmark conveys the differences in the role of individual groups by dividing muscles into local and global (17).

Among the group of local muscles author ranks the multifidus muscle of lumbar region as well as the transverse abdominal muscle. Local muscles have been defined as such which stick directly to the vertebrae and hence working in co-contraction (synergy, synthony and synchrony) have high ability to increase the stiffness of the segment and to reduce the so-called neutral zone (14, 15). Among the group of global muscles Bergmark ranks: rectus abdominis and abdominal oblique muscles, erector spinae as well as quadratus lumborum muscle. Global muscles have no direct impact on the stability of the spinal motion segment, they are situated in some distance from it and because of that have great potential of generating torques.

Based on the above classification two specific types of the low postural tone have emerged. Children with reduced tension of the deep trunk muscles (local) that is compensated by excessive tension of superficial muscles (global) have been rated among the first group (fig. 2 a,b) (18-21).

Active subsystem, and specifically global muscles, is excessively used for stabilization in this type of tone. Panjabi indicates that abnormal use of the muscles to provide stability will lead over time to overload and secondary dysfunctions within „abused" muscle group (14, 15).

The issue of some muscles taking over the functions in situation of weakening of the others is also seen in the

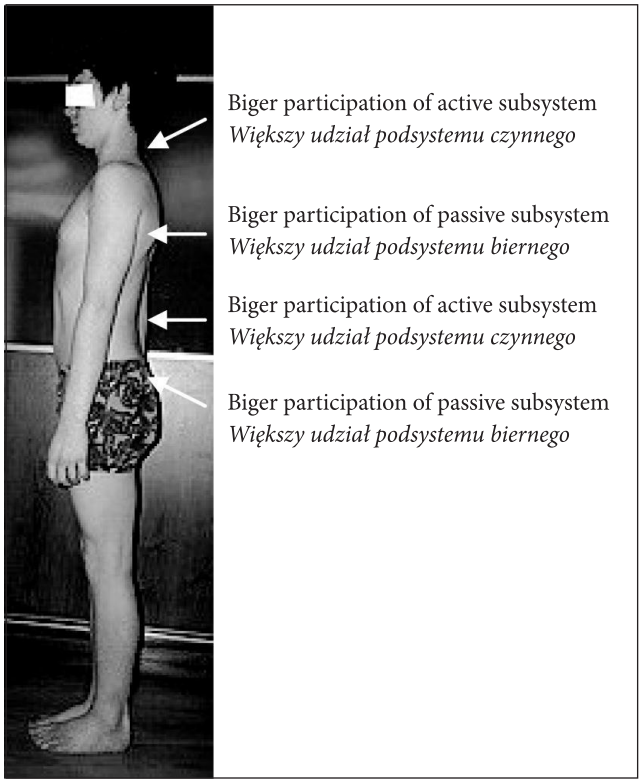

Fig. 1. Upright maintenance of the vertebral column axis at diverse participation of the passive and active subsystems structures of body stabilization based on Myers and Panjabi theory.

Ryc. 1. Utrzymywanie osi kręgosłupa w pionie przy zróżnicowanym współudziale struktur biernego i czynnego podsystemu stabilizacji ciała w oparciu o teorię Myersa i Panjabiego.

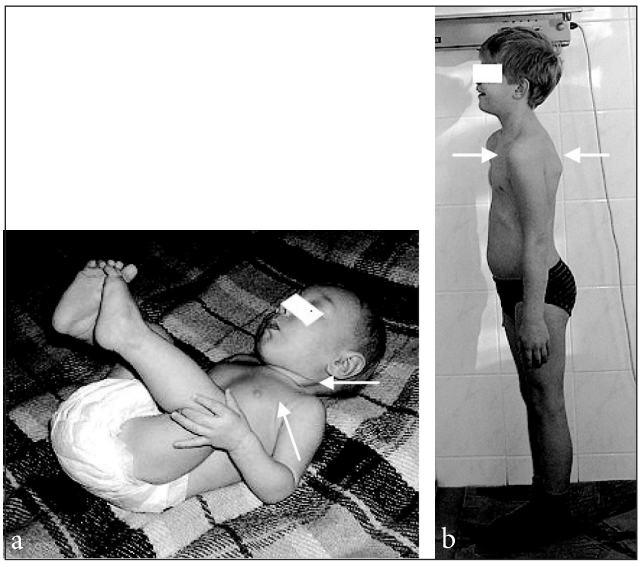

Fig. 2. Increased superficial muscles tension within the shoulder girdle. a) in the infant (sternocleidomastoid muscle, thoracic muscles); b) in the older child (thoracic muscle, levator scapulae muscle).

Ryc. 2. Wzmożone napięcie mięśni powierzchownych w rejonie obręczy barkowej. a) u niemowlęcia (mięśnie mostkowo-obojczykowo-sutkowaty, piersiowe); b) u dziecka starszego (mięśnie piersiowy, dźwigacz łopatki).

studies of Snijders and Vleeming (22-25). The authors associate low back pain with abnormal use of the ligaments and muscles, which stabilize the lumbar segment of the spine.

It can be also assumed that as a result of tone reduction in the muscles responsible for stabilization, increased active stiffness of the muscles occurs in order to protect the joint from damage (26).

Children with both deep (local) and superficial (global) muscle tone decrease fall into the second group. This group does not present diagnostic problems, because these children demonstrate the picture of general hypotonia. Janda's observations, which indicate the existence of tone disorders of weaken muscle force character, have been used to emerge this type of tone (27). Compensation of this type of low postural tone triggers the necessity for using the second subsystem distinguished by Panjabi that is passive subsystem. Body stabilization in considerable degree is based on the shape of the bones, spatial orientation of joints surfaces, ligaments, joint capsules, intervertebral discs, meniscus as well as the passive properties of the muscle tissue (passive stiffness) (fig. 3 a,b).

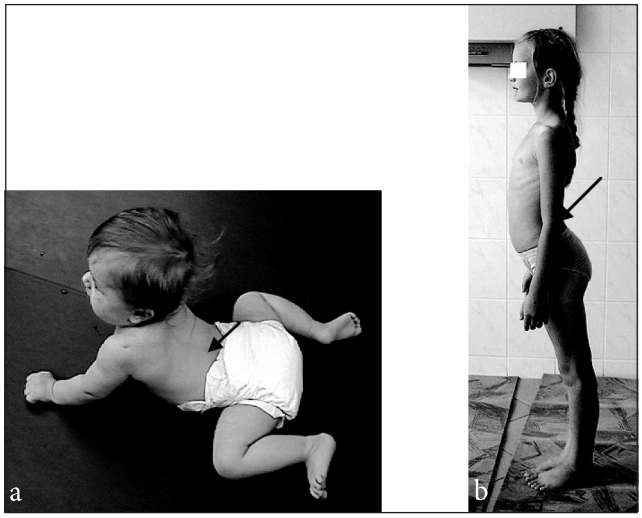

Fig. 3. Compensatory use of spatial orientation of joint surfaces for body stabilization in the lumbar segment: a) in the infant; b) in the older child.

Ryc. 3. Kompensacyjne wykorzystanie do stabilizacji ciała przestrzennej orientacji powierzchni stawowych w odcinku lędźwiowym: a) u niemowlęcia; b) u dziecka starszego.

As a part of accurate communication, the authors propose using the term spastoidal type to describe children that use active subsystem attributes for verticalization and atetoidal type that is based on the passive subsystem (28-30).

SUMMARY

Infancy is fundamental for the quality of the body posture development. On one hand it prepares muscles to perform specific functions, on the other creates peculiar program of the posture control, which will be used by human in the subsequent developmental stages. The quality of the posture tone may be recognized already in infancy and with high plausibility prognosis, which type of posture will be developed later in life. Children from broadly defined standard present substantial differences in respect of use of the stabilization subsystems due to basic potential of the postural tone. This underlies such substantial diversity of the body postures. The body posture of the infant with normal tone (normotonia) (fig. 4a) was collated below with two infants with low tone of the deep stabilizers of the trunk and diverse qualities of the compensatory active (fig. 4b) and passive (fig. 4c) mechanisms.

The child with normal tone as a result of the activity in the proper patterns gradually gains development of the segmentary control as well as spatial orientation of the individual segments and the whole body which create basis for the normal posture development (fig. 5a). The other two examples illustrate abnormal movement activity due to improper preparation of the individual subsystems to fulfill stabilization function. In the spastoidal type development of the faulty posture may be forecasted with such features as: shift of the head before the line of the shoulders, high alignment of the shoulders girdle, increased thoracic kyphosis (fig. 5b).

Whereas in the case of children with the atetoidal type faulty posture arises with such features as decreased thoracic kyphosis, increased lumbar lordosis, knee joints hyperextension, valgus knees and feet (fig. 5c).

Diagnosis of the characteristics of the low postural tone obligates to introduce the neurodevelopmental management in order to implement proper solutions in the scope of body stabilization. Frequent postponement of the management dictated by the hope that the child will spontaneously balance the developmental abnormalities

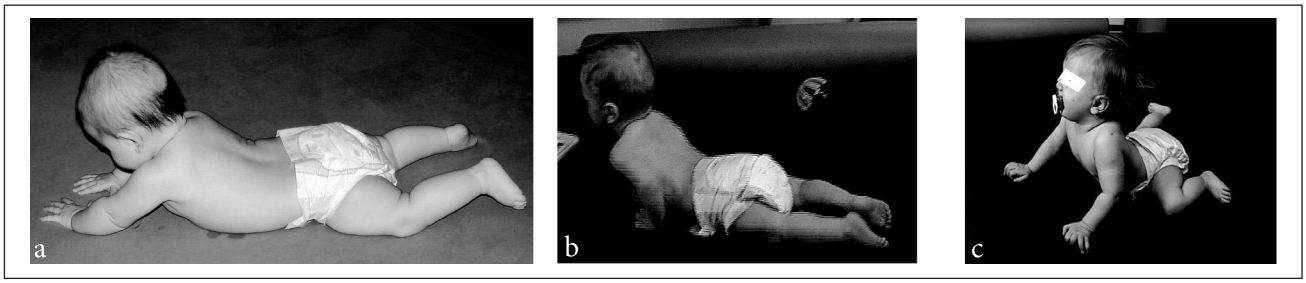

Fig. 4. Diverse qualities of the postural tone in infants: a) normotonia; b) spastoidal type; c) atetoidal type.
Ryc. 4. Zróżnicowane cechy napięcia posturalnego u niemowląt: a) normotonia; b) typ spastoidalny; c) typ atetoidalny.

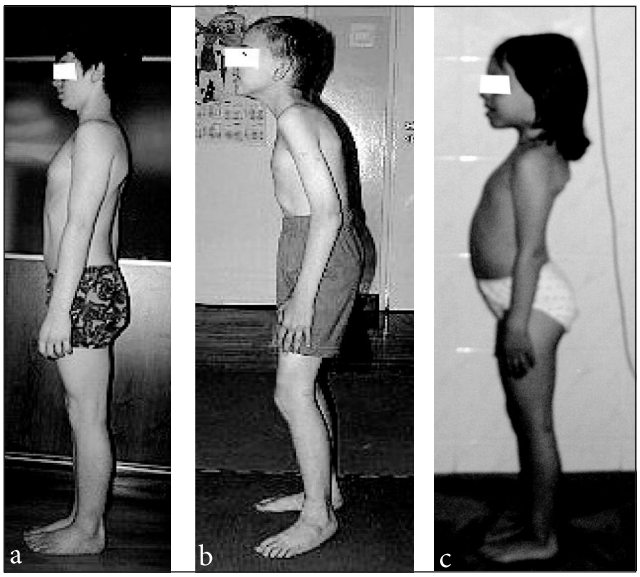

Fig. 5. The quality of body posture in children with different types of postural tone: a) the child with normal tone (normotonia), without compensation characteristics; b) the child with the spastoidal type and active compensation; c) the child with the atetoidal type and passive compensation.

Ryc. 5. Jakość postawy ciała u dzieci z różnymi typami napięcia posturalnego: a) dziecko z napięciem prawidłowym (normotonią), bez cech kompensacji; b) dziecko z typem spastoidalnym i kompensacją czynną; c) dziecko z typem atetoidalnym i kompensacją bierną.

is a mistake, because each developmental stage constitutes the foundation for the subsequent one and creation of the normal basis is the condition of the developmental process success. If abnormalities accumulate, structural changes will occur over time and physiotherapy intervention may be ineffective. It is worth emphasizing that consequences of the abnormal compensatory changes are of "treacherous" character. Our bodies can frequently compensate adaptive processes without distinct symptoms until adaptive abilities of the tissues will be exhausted. At this point, decompensation arises and the symptoms become visible: pain, contractures, limitation of the range of mobility. As the compensatory mechanism progresses, adaptive abilities of the body become exhausted which triggers permanent dysfunction (5).

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Author's contributions/Wkład Autorów
According to the order of the Authorship/Według kolejności

Conflicts of interest/Konflikt interesu
The Authors declare no conflict of interest.
Autorzy pracy nie zgłaszają konfliktu interesów.

Received/Nadesłano: 05.11.2013 r.
Accepted/Zaakceptowano: 30.12.2013 r.

Published online/Dostępne online

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