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Optimization of early physical rehabilitation of patients with spastic infantile cerebral palsies

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Infantile cerebral palsy is an urgent issue of pediatric neurology all over the world. Adequate choice of the term and methods of rehabilitation helps children with this pathology to adapt to the society and improves prognosis of motor and mental development thereof. The article presents the optimal methods of physical rehabilitation at early stages of a child's development based on the current understanding of neuroplasticity, reserve capabilities of a developing brain, as well as of pathophysiological aspects of recovery and compensation of the damaged structures of the central nervous system. The authors demonstrate crucial differences between approaches to rehabilitation of children under and over 2 years of age. Despite the selected methods of rehabilitation of children with infantile cerebral palsy, successful results of the therapy require a multidisciplinary approach characterized by early onset, balanced combination of methods of physical rehabilitation and drug therapy, physiotherapy and psychological-pedagogic support.

Keywords: *neuroplasticity, infantile cerebral palsy, rehabilitation, children, spasticity, kinesio taping, Vojta method.*

INTRODUCTION

Understanding of physiological principles of neuroplasticity and functional reserves of a developing child's brain is a starting point for planning effective rehabilitation measures in children with central nervous system (CNS) damage and risk of infantile cerebral palsy (ICP). The doctor's objective in such a case is to help a child use the available CNS reserves, preserve, develop and adapt the available functional capabilities by employing current means of rehabilitation. Understanding the scale of brain neuroplasticity, especially in early childhood, lays heavier responsibility on participants in the process of rehabilitation. Correct choice of a method of neurorehabilitation and timely application thereof is as important as prescription of drug or surgical therapy.

METHODS OF NEUROREHABILITATION

Many methods of rehabilitation conventionally applied for medical rehabilitation of the children with pathological muscle tone alterations (especially spastic alterations), are becoming scientifically substantiated from the perspective of neuroplasticity. However, scientific knowledge of the nervous system's reserves and capabilities is becoming more extensive with each passing day; this results in the need in continuous revision, reevaluation and improvement of the current and reintroduced methods of rehabilitation [1].

In order to implement the current methods of rehabilitation to the fullest extent possible, it is necessary to resolve the issues hindering development of a new, more functionally advantageous movement pattern. One of the most significant problems hindering development of movement functions at ICP is spasticity. The increase in muscle tone gradually leads to limitation of functional capabilities, formation of movement deficiency and impaired movement skill acquisition; complicates self-maintenance; contributes to development of pathological processes, contractures, incomplete and complete dislocations of joints. Spasticity may effectively result in a whole range of motor disturbances, and sometimes even in immobility of a patient [2].

Timely alleviation of spasticity contributes not only to prevention of orthopedic complications and improvement in the patient's motion activity, but also to rational selection of further rehabilitation measures.

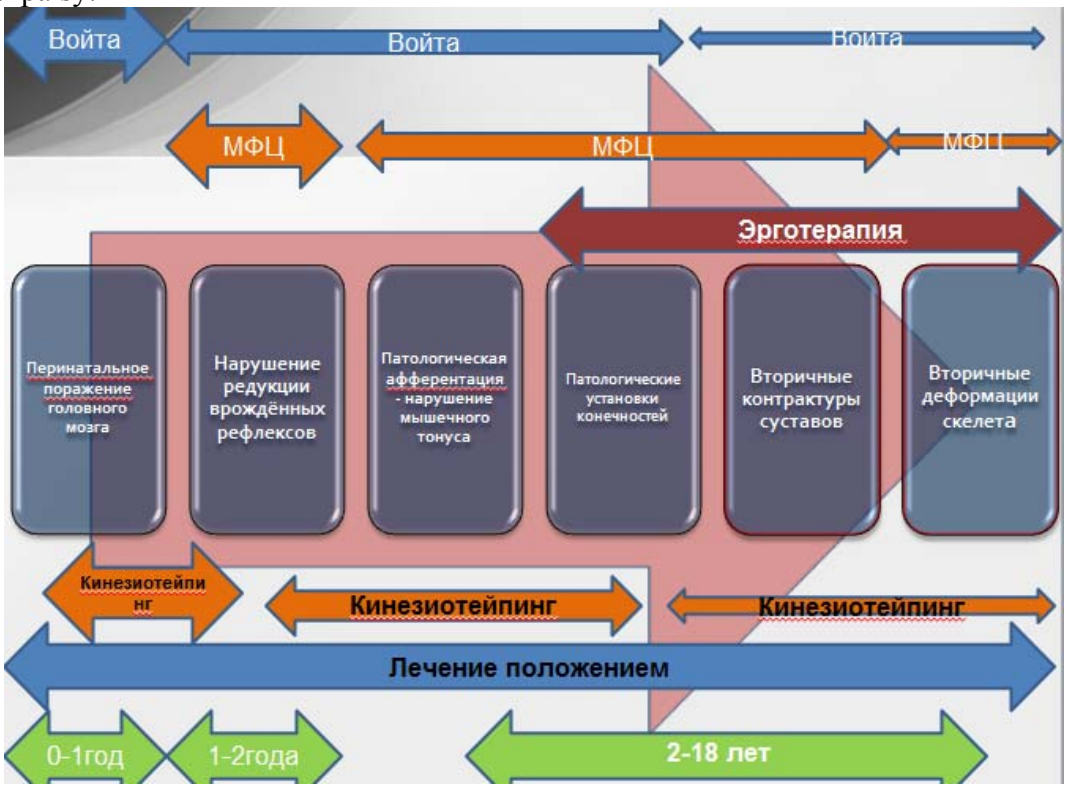
The following methods of spasticity correction have been developed and are employed [3]:

• functional neurosurgery, including destructive operations (peripheral nerve transection, dorsal selective rhizotomy, selective destruction of deep brain structures) [4-6];
• neuromodulatory operations (intrathecal administration of baclofen);
• chronic epidural spinal cord stimulation;
• oral antispastic drugs;
• local injections of botulinum toxin type A into spastic muscles;
• methods of physical rehabilitation, physiotherapy and natural factors (pic. 1) [8].

Apart from spasticity, reciprocal inhibition disorders, development of pathologic synergies and synkinesis, increase in reflex excitability (intensified startle response) and presence of pathological tonic reflexes (tonic labyrinthine, symmetrical tonic neck, asymmetrical tonic neck reflexes), which are especially intensive when a person changes his/her body's position, play and important role in the development of a pathological movement pattern at ICP.

An optimal complex of methods considers all the listed aspects of motor disturbances in children with ICP.

Pic. 1. Stages of application of physical rehabilitation methods for motor disturbances at infantile cerebral palsy.



NOTE. Translation of the terms in the table

Войта	*Vojta*
МФЦ	*MFC (myofascial chains)*
Эрготерапия	*Ergotherapy*
Перинатальное поражение головного мозга	*Perinatal brain damage*
Нарушении редукции врождённых рефлексов	*Impaired congenital reflex reduction*
Патологическая эфферентация – нарушение мышечного тонуса	*Pathological efference – muscular tone disturbance*
Патологические установки конечностей	*Pathological limb postures*
Вторичные контрактуры суставов	*Secondary joint contractures*
Вторичные деформации скелета	*Secondary skeletal deformities*
Кинезиотейпинг	*Kinesio taping*
Лечение положением	*Position treatment*
0-1 год	*0-1 years of age*
1-2 года	*1-2 years of age*
2-18 лет	*2-18 years of age*

AGE-RELATED ASPECTS OF NEUROREHABILITATION

Two age periods may be distinguished for clarity in neurorehabilitation of children with perinatal CNS damage. Botulinum therapy features certain restrictions on use in under-2 children; also, massive neuroorthopedic and neurosurgical interventions are not desirable. At the same time, the potential of neuroplasticity remains high. Complex rehabilitation of over-2 children may involve botulinum therapy for focal alleviation of spasticity; this helps to adapt the child to the developed movement pattern and inhibit progression of orthopedic complications.

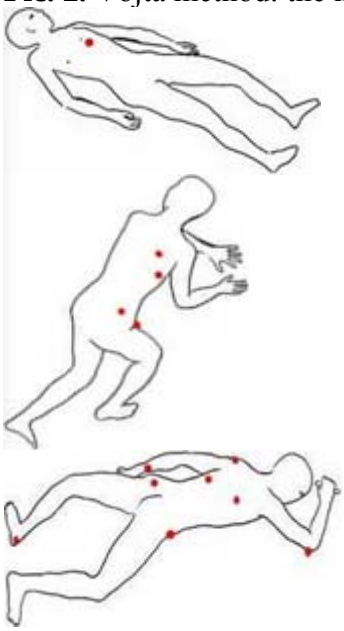
Rehabilitation in under-2 children is aimed at development of a physiological movement pattern in the setting of suppression of pathological tonic reflexes, maintenance of length and elasticity of tendons and muscles affected by pathological tone increase and prevention of joint contractures. Use of oral antispastic drugs in this age group is often limited due to progressive side effects (sedation and nonselective tone reduction) hindering development of a movement pattern due to afferent kinesthetic information perception deterioration. Effective methods of movement pattern development in such a case are Vojta method and exercise therapy imitating physiological postures of healthy children.

Vojta method

Vojta method can be employed in the youngest children (from the first month of age). Czech neurologist V. Vojta developed diagnostic and therapeutic principles of this method in the 1950s. The author assumed that each person has a physiological movement pattern from birth. The method is based on reflex locomotion, which implies use of crawling and self-righting reflexes, i.e. partial patterns in charge of posture, gravity resistance and movement, for rehabilitation (pic. 2).

Reflex locomotion method is aimed not at refinement of a certain movement, but at development of coordinated work models for autochthonous and limb muscles; these models will later be used to establish a chain of necessary movements. The exercise consists in securing a child in a specific posture and placing pressure on a selected area with the hand. The area is selected on an individual basis depending on motor disturbances and response. Parents are mandatory participants of the process; they learn the method's principles in the process of rehabilitation and continue the therapy at home. Vojta method is aimed not only at developing certain ontogenetic skills, but also to stabilize pelvic, head and spinal posture, which is why therapists may resort to it at subsequent stages of development as well.

Pic. 2. Vojta method: the main stages.



Reflectory self-righting: stage 1

Reflectory self-righting: stage 2

Crawling reflex

Suppression of pathological tonic reflexes in certain postures is not always sufficient, which is why the therapy is supplemented with position treatment. Fetal position is actively used from the first month of life, as it helps to suppress symmetrical tonic neck reflex; at an older age (11 months) the following position is often used: placement of cushions along the spine and under the sacrum, thigh separation and use of weights to secure limbs in the correct position. Parents are taught to put children in these positions and handle them correctly considering their individual peculiarities. These postures and positions are recommended for daily use at home for purposes of suppressing tonic reflexes, preserving natural (hip, shoulder, vertebral) joint mobility and maintain muscle length (e.g., of hip adductors). Special attention is given to selection of the child's correct position when sitting or being carried in arms, as well as to ontogenetic succession of development, prevention of early verticalization, especially when crawling and steady sitting skills have not been developed yet [9].

If the child characterized by spastic tone increase and no skills of turnover or crawling attains the age of 1 year, the rehabilitation program is supplemented with manipulations with myofascial chains [10] focused at extreme physiological positions of joints in the setting of maximum approximation of joint surfaces in large (shoulder and hip) joints and eccentric work of muscles, which is especially important for preserving muscle and tendon length and restoring the optimal length-extensibility ratio in spastic muscles. Prestart postures, where all the muscles involved in the future movement and all the joints affecting it are in a biomechanically advantageous position for gravity resistance, are actively used. Postures are reproduced in their entirety, in the setting of suppression of tonic reflexes and imitate postures of healthy children with gradual reduction in the breadth of stance, increase in stress on the child's limbs and reduction in internal support for the child to sense his/her weight in space. Head, spinal and pelvic postures are controlled in all the positions.

The brain perceives the flow of simultaneous afferent impulses from all the joints and muscles involved in the prestart posture; extensive networks of frontal and parietal hemisphere neurons, basal ganglia and cerebellum are involved; synaptic activity becomes more intensive; grey matter undergoes structural changes affecting perception and integration of visual and somatosensory information. Numerous neurons and links thereof excessive at early stages of development and lost in the process of normal ontogenesis may be preserved and, provided they function regularly, involved in formation of compensatory links in the process of rehabilitation at

perinatal brain damage. Establishment of prestart postures models a specific course of further function of these reserve neurons.
Exercise therapy for children consists of courses of 7-10 procedures every 2-3 months or is performed continuously (2-3 times per week) until the child attains the age of 2 years. The exercises involve parents on an active basis; they are taught simple postures, which can be reproduced without professional assistance in the course of the day, and urged to use orthopedic devices.

KINESIO TAPING

It is widely known that even a short immobilization of different limb muscles leads to reduction in cortical representation thereof [11]; this is just another demonstration of lability of plastic changes in the cerebral cortex due to external factors. That is why it is extremely important to ensure maximum freedom of movement in distal parts of limbs immediately after the exercises while preserving correct posture of joints. It has become possible when kinesio taping was introduced to pediatric rehabilitation by Japanese doctor Kenzo Kase, who deemed continuous positive therapeutic intervention between physician visits necessary. After 6 years of clinical studies, the method was registered in 1979 and gained international recognition during the Seoul Olympic Games (1988). Dr Kase proposed using elastic tapes affixed to skin in a direction and with tension applicable to treatment purposes. Tapes stimulate skin receptors and indirectly affect deep structures through skin, superficial (subdermal) and deep fascia. 10 minutes after application, kinesio tape is not felt on the skin; the only thing a person feels is its action: the tape tends to contract, thus stimulating or irritating mechanoreceptors (depending on tightness).
Stimulation of mechanoreceptors forms a continuous afferent kinesthetic impulse flow reporting to the brain of the joint posture between the procedures. Use of different taping techniques helps to optimize and individualize the process of rehabilitation. The following kinesio taping techniques are used in children with spastic tone increase:
1. Mechanical correction. Used for physiological biomechanical joint axis (e.g., of the hand) reconstruction. Kinesio tape tightness – 50-75% (pic. 3).

Pic. 3. Thumb adduction before botulinum therapy (a), after botulinum therapy (b) and application of a kinesio tape (c).

a b c

2. Functional correction. Used for partial pathological movement restriction and physiological movement reinforcement. Tightness – 50-75%.
3. Muscular kinesio taping. Used for muscular stimulation or relaxation. Tightness – 15-35%. Techniques may be combined in one child.
Further, if a child characterized by focal spasticity attains the age of 2 years, the therapy is supplemented with administration of botulinum toxin to certain muscles. Children form their movement strategy by that age [12]. Physical rehabilitation methods must be focused not at attempting to normalize this strategy (which is usually infeasible), but at accomplishing specific objectives in each individual case: work with shortened muscles, large joint axis stabilization and control over the muscles involved in the physiological movement. Vojta method is used to stabilize pelvic and spinal postures and activate the autochthonous muscles. Physical

rehabilitation is supplemented with training using exercise machines with biological feedback, which help to control strength and speed of movement. Suspension systems (e.g., Ugul) are used to work with patients with lightweights when necessary.
Kinesio taping is also effective in over-2 children; it is used in botulinum therapy in order to reinforce physiological movement and partially restrict pathological movement (functional correction). Muscular kinesio taping is used to stimulate and support weak muscles and block work of the spasticity-subject muscles, “mechanical correction” – to correct biomechanical joint axis (e.g., of carpometacarpal joints, thumb abduction).

CONCLUSION

Consistent use of the aforementioned methods of physical rehabilitation considering peculiarities of motor and proprioceptive disturbances of a child in combination with correct work with parents helps to implement potential movement capabilities of each patient as successfully as possible. Multidisciplinary approach to rehabilitation of children with the ICP characterized by early onset, balanced combination of methods of physical rehabilitation and drug therapy, physiotherapy and psychological-pedagogic support helps to adapt children to the society as well as possible.

CONFLICT OF INTEREST

The authors have indicated they have no financial relationships relevant to this article to disclose.

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